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NAME OF AUTHOR/*NOM DE L'AUTEUR* John W. Ives

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NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* Dr Clifford G Hickey

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A Spatial Analysis of Artifact Distribution on a Boreal Forest Archaeological Site

by

© John W. Ives

A THESIS

Submitted to the Faculty of Graduate Studies and Research in
Partial Fulfilment of the Requirements for the Degree

Master of Arts

Department of Anthropology

Edmonton, Alberta

Fall, 1977

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled

A Spatial Analysis of Artifact Distribution on a Boreal Forest Archaeological Site

submitted by John W. Ives

In partial fulfilment of the requirements for the degree of

Master of Arts

Supervisor

Charles Schweger

N J Byrne

June 15, 1977

ABSTRACT

The Eaglenest Portage Site (alternately referred to by the briefer Borden designation, HkPa 4), is a large site located in the Birch Mountains region of northeastern Alberta. Extensive excavations aimed at obtaining a glimpse of the spatial structure of artifact distributions on the site were carried out during the summer of 1976. An assemblage dominated by simple flake tools and debitage was recovered. The site has been occupied over the last two millenia and comparisons have been made with assemblages from the areas North and East of the Birch Mountains.

Boreal forest sites like HkPa 4 often have no cultural or natural stratigraphy by which essentially synchronic components can be identified. When artifacts recovered indicate considerable time depth, as is the case here, it is not valid to assume that an excavation sample will yield a synchronic component. Fortunately, the horizontal relationships between artifacts have characteristics allowing some control over temporal variability. The potential processes operative in the formation of the archaeological record at HkPa 4 are considered in an effort to segment artifact distributions into spatially discrete, synchronic clusters believed to be generated by artifact manufacture, use, and discard. It is clear that the archaeologist's impression of prehistoric socio-economic activity is obscured by a number of other cultural and natural factors.

The nature and significance of the spatial patterning of artifact distributions are explored by three techniques: mean square block analysis, order neighbour statistics, and density contouring. Results indicate that finished artifact distributions are significantly aggregated, tending to occur in groups of two to nine items. Artifact densities are low, and in view of the contagious distributions demonstrated, an attempt is made to define spatial clusters of artifacts by cluster analysis. Spatial association and correlation is examined amongst the spatial clusters defined. Spatial clusters have attributes and these permit us to speak of different kinds of clusters.

Because of inherent difficulties such as synchronic/diachronic cluster overlap, only about two-thirds of the data recovered can be submitted to complete analysis. For this data, it is possible to speak of basic synchronic artifact groups. A larger sample would make possible a better understanding of temporal variability on unstratified Boreal Forest sites. Results suggest that not all spatially discrete artifact clusters can be equated with tool kits from activity areas and that lithic manufacture itself may be the most important source of spatial patterning at HkPa 4.

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CHAPTER I.

INTRODUCTION

HkPa 4 is a large unstratified site from the Boreal Forest of northern Alberta. It was discovered during the course of a survey of the Birch Mountain region conducted by Paul Donahue (1976) during the summer of 1975. At that time, artifacts were found eroding from the top of a cutbank along the edge of the stream on which it is located. Subsequent testing (with fourteen 0.25 by 0.25 meter test pits) indicated that the site was comparatively rich, and 279 artifacts were recovered.

The excavation of HkPa 4 provided an excellent opportunity for the recovery of data basic to the culture history of northeastern Alberta while permitting glimpses of the spatial structure of artifact distributions on an extensive, fairly flat site. During the summer of 1976, a four person crew undertook intensive excavation of HkPa 4. The information recovered at that time is used in the spatial analysis described here. The location of HkPa 4 and the study area appear in Figure 1.

Boreal Forest Sites

The Boreal Forest archaeologist is frequently faced with the problem of thin, veneer type sites with comparatively impoverished artifact assemblages. At the same time, soil conditions prevent the preservation of less durable remains. We are faced, therefore, with rudimentary archaeological data from which the archaeologist must make inferences about information he might ordinarily recover in other locations.

The central dilemma with the data that can be recovered is the stratigraphic compression of chronologically distinct artifact assemblages. Normally, there is little vertical separation of components, making their distinction on a site wide basis impractical.

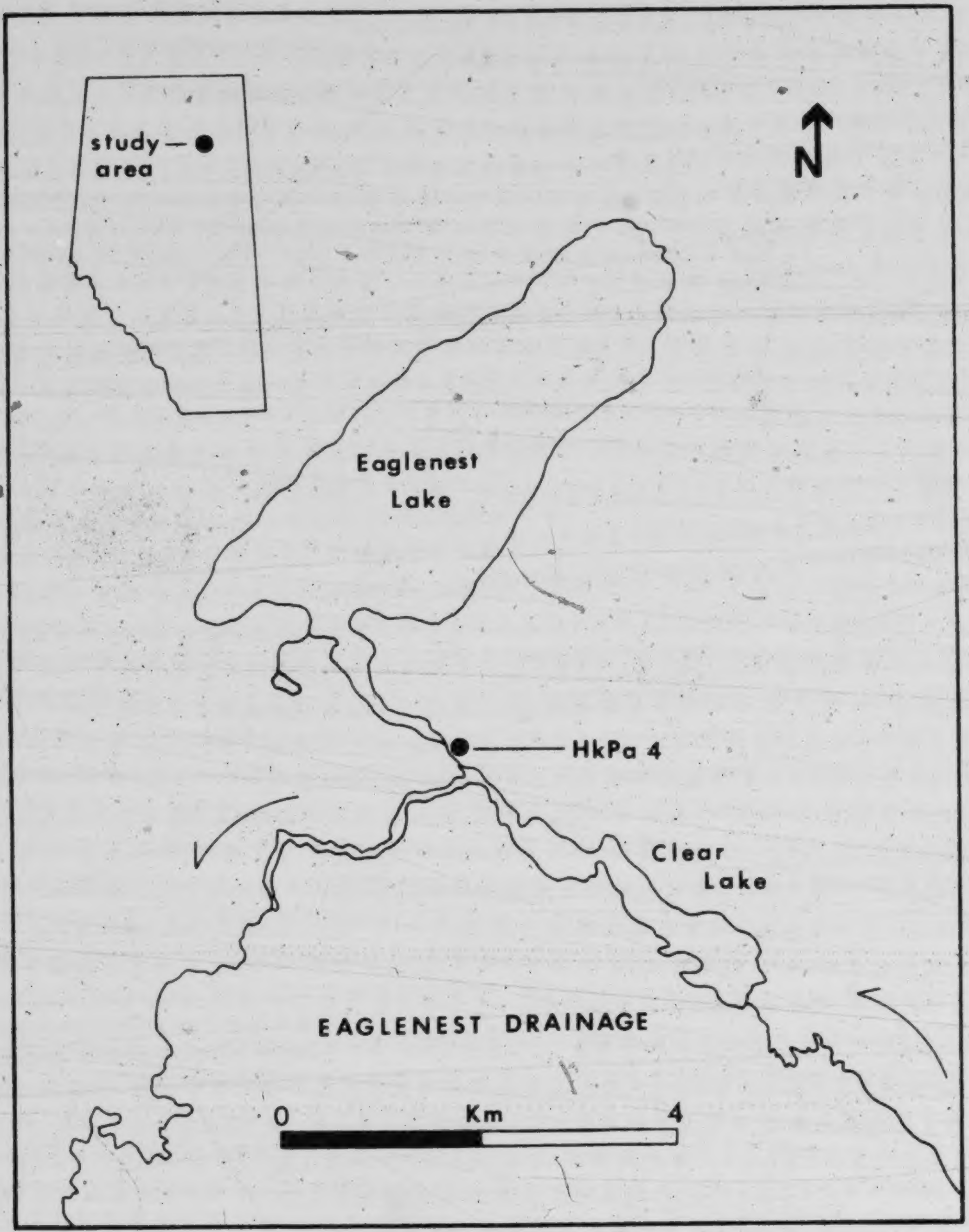

study area
N
Eaglenest Lake
HkPa 4
Clear Lake
EAGLENEST DRAINAGE
0
Km
4

Figure 1. Location of HkPa 4 on the Eaglenest drainage: 57° 44' 46" N. Lat. x 112° 09' 00" W. Long. Ne¼, S1, T 101, R 14, W 4. Elevation is approximately 735 meters above mean sea level.

To date, the trend in preliminary studies has been to recognize this problem, but ignore its consequences. Morlan's (1974) nearest neighbour analysis at the Gladstone Site and Minni's (1976) work at Black Lake are among the all too few attempts to assess the spatial aggregation of artifacts in Boreal Forest sites. Wright (1972:1) assumes that small and disturbed samples must be valid until disproven and that whole sites may be treated generally as components with limited time depth. However, human occupation of a site is often recurrent because of the geographic and ecological reasons which made it a site in the first place, and such assumptions may not always be reasonable. Data of diachronic significance can be distorted if a site assemblage is treated as a single component merely because it is assumed to be synchronous. In the case of HkPa 4, a preliminary analysis suggested that significant temporal differences existed. This is borne out by the results of excavations. There are countless sites like HkPa 4, yet the data they hold cannot be fully exploited without the recognition of temporal heterogeneity and some means of assessing it. As we shall see, the comparatively low density of artifacts in Boreal Forest sites can be turned into a definite advantage.

Difficulties can be avoided, at least to some extent, by recognizing artifact distributions within the site as a significant data resource. Spatial analysis of artifact distributions provides a means for resolving a number of problems in component purity and synchroneity. The distribution map has been an important archaeological tool for many years, yet archaeologists have failed to capitalize upon intrasite distributional data. In Daniel's words,

> The distribution map is one of the main instruments of archaeological research and exposition, but because it is a commonplace of books and papers, do not let us forget what it is trying to do--to accomplish and to demonstrate the totality of information about some archaeological fact, to study the total evidence in space regarding one aspect of the material remains of the past (Daniel 1962:80).

Often, analysis has proceeded by a visual inspection of distributional data followed by a subjective evaluation of the significance of spatial patterning. However, archaeologists now have at hand statistically objective methods for evaluating the nonrandomness of artifact distributions. As Harvey pointed out:

> It has been shown that the ability of the map-user to discriminate and evaluate the information contained in the map is not free from subjective elements and that the more information contained in a map the more ambiguity and uncertainty there is likely to be as regards the interpretation to be put upon it (Harvey 1969:377).

Statistical methods have the advantage of rigorously measuring nonrandomness and can thereby allow objective consistency in defining artifact clusters. Furthermore, these techniques are replicable.

Formation of the Archaeological Record

Clarke (1968:648) notes two fundamentally opposed views of archaeological data. On the one hand, archaeological materials can be seen as formerly playing an integral part in sociocultural entities, in "systems in which the artifacts were elaborately networked". Concomitantly, archaeological data cannot be studied as an artificially discrete subsystem, but rather, must be viewed in social and environmental context. On the other hand, archaeological data can be seen as static, divorced from its original behavioral and environmental context. As such, it is best studied empirically as a "material phenomenon with observable regularities".

There is little question that the first viewpoint has had great impact upon recent trends in archaeology. If technology is regarded as a critical interface between human societies and their environments, a dynamic interpretation of artifacts once "embedded" in a sociocultural system can lead directly to an understanding of that system. Binford has made some of the strongest assertions supporting this position:

> ...the intimate systematic articulation of localities, facilities, and tools with specific tasks performed by social segments results in a structured set of spatial-formal relationships in the archaeological record (Binford 1964:425).

Or, more explicitly,

> The loss, breakage, and abandonment of implements and facilities at different locations, where groups of variable structure performed different tasks, leaves a "fossil" record of the actual operation of an extinct society (ibid.).

That the archaeological record is spatially and formally structured is hardly a contentious statement today. The interpretation of this structure is another matter, and justifiable questions arise about which extinct operational processes have become "fossilized". In their Mousterian studies, Binford and Binford (1966:241) express the sentiment that "the structure and content of an archaeological assemblage is directly related to the form, nature, and spatial arrangement of human activities" (emphasis mine). The "specific tasks" and "human activities" they refer to are divided into maintenance and extractive tasks, the former involving activities related primarily to the nutritional and technological requirements of the group, while the latter are related to the direct exploitation of environmental resources (Binford and Binford 1966:291). Yet, how confident can we be that the archaeological record represents these activities accurately? Very simply, there is no particular reason for confidence, and recently Binford (1973; 1976) reversed this original position and began an examination of the factors leading to the formation of the archaeological record.

An analogy is appropriate. The interpretation of artifact assemblages is fraught with much the same difficulties found in the interpretation of paleontological assemblages. The study of the processes by which assemblages of bones are modified, redistributed, and buried is termed taphonomy. As early as 1940, Efremov stressed the indissoluable unity of both biological and geological points of view for integrating the study of fossil beds (Dodson 1971:53). Death processes and geological processes exert a strong influence on the fossil assemblage ultimately recovered by the paleontologist. The taphocoenosis, the set of fossil traces buried in a particular stratum, invariably differs in qualitative and quantitative composition from the living biota (biocoenosis) of the area and time period from which it came (Howell 1976:237). With the proviso that cultural transformations become infinitely more complex, it is clear that artifact assemblages do not stand in a direct relationship to the activity areas and tool kits in which archaeologists currently express such interest.

If paleoecological reconstruction of extinct ecosystems must have taphonomy as a prerequisite, "paleoanthropology" must recognize the difference between the archaeological record and prehistoric social activity. For example, in discussing the theory of spatial analysis in archaeology, Whallon (1973a:117) argues that tool types will be differentially distributed at sites, that groups of tool types will be mutually correlated over their distribution patterns, and that these groups represent functionally associated tool kits used in the same activities. This could only be true if all ongoing natural and cultural processes came to a complete halt. Mutual correlation could just as well result from the frequent but accidental association of functionally unrelated artifacts in refuse areas, a situation paralleling the thanatocoenosis (death assemblage) concept (Shotwell 1955:329).

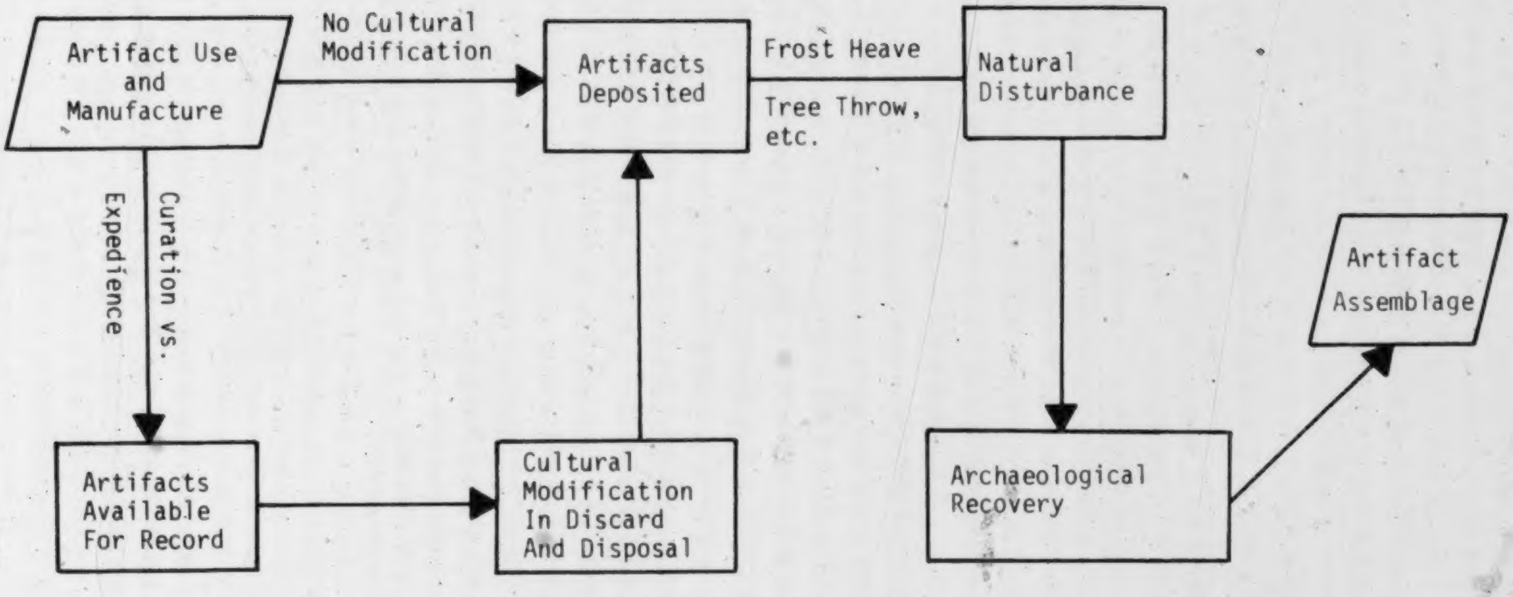
Schiffer (1976:12) offers the principle that archaeological remains are actually a distorted reflection of past behavioral systems. At the same time, these distortions may be regular, and systematic (not necessarily direct) relationships likely exist between archaeological remains and past cultures. Archaeological data share three basic properties:

1. They consist of materials in static spatial relationships.
2. They have been output in one way or another from a cultural system.
3. They have been subjected to the operation of non-cultural processes (Schiffer 1976:12).

Processes active in the formation of the archaeological record are depicted schematically in Figure 2.

In view of recent trends in archaeological theory, the static nature of the spatial relationships between artifacts cannot be overstressed. The human processes that generate artifact distributions are irrevocably lost, a situation which Leach (1973:765) likens to the "black box" in General Systems Theory. The second view proposed by Clarke is the essence of archaeological data. The first view he proposes is an optimal goal only to be approximated when potential distortions in the data are well understood and when strong inferences from the data are possible.

Schiffer's second point also bears emphasis. The last cultural process contributing to the archaeological record is artifact disposal. The disposal process has two stages. Binford (loc. cit.) directs his attention to the first stage: the attributes of the artifact and the context of its use determine its availability for discard. Technologies in which tools are efficiently retained and transported are termed curated. Technologies in which tools are easily and frequently discarded



Artifact Use and Manufacture
No Cultural Modification
Artifacts Deposited
Frost Heave
Tree Throw, etc.
Natural Disturbance
Curation vs.
Expedience
Artifacts Available For Record
Cultural Modification In Discard And Disposal
Archaeological Recovery
Artifact Assemblage

FIGURE 2. Processes leading to the formation of the archaeological record.

subsequent to their use are termed expedient. While ethnography suggests that no recent technology can be characterized as wholly curative or expedient, it seems clear that overall decisions about discarding tools directly affect the composition of the archaeological record. In the case of careful curation,

> ... the archaeological record is more properly considered a record of the organization of entropy as opposed to the organization of the ongoing activity structure of the group (Binford 1973:242).

Once an artifact has become available for the archaeological record, cultural processes can further transform its spatial relationship with other artifacts. If the discarded artifact is treated as refuse, the potential exists for further modification of its associations and location. Even if artifacts are not singled out as refuse, modification can still occur through processes as simple as trampling underfoot.

The noncultural processes to which artifacts are subjected are of the same quality (though seldom of the same scale) as those that fossil bones may undergo during deposition. Various kinds of artifacts can be lost from the archaeological record through the action of biophysical factors. Again, biophysical factors are capable of distorting spatial relationships. Finally, archaeological recovery also affects the nature of the archaeological record, occasionally in fashions less readily grasped. Different sampling strategies (Chapter V) are a case in point. Let us now consider processes relevant to the formation of the archaeological record at HkPa 4, and the effect they have upon our understanding of the spatial structure of artifact distributions at that site.

Hypotheses

1. The range of human activities which have taken place at HkPa 4, from artifact manufacture and use through discard and disposal, have contributed to patterning and structure in artifact distributions there.

This hypothesis might be untrue if site users practised total curation. However, as Whallon (1973a:118) suggests, it is almost a certainty that no technology is wholly curative _or_ expedient. If the modern Nunamiut can be characterized as technological curators (Binford 1976:338), I believe it is fair to say that a number of investigators (e.g., Honigmann 1946:35ff.,61; Spencer and Jennings, _et al_. 1965:106-109) would concede the hallmarks of aboriginal Athapaskan technology to have been simplicity, efficiency (not in recycling artifacts, but in terms of the limited effort expended to achieve results), and expediency. Hence, it is unlikely that artifact distributions will be random, and it is more reasonable to anticipate that structured human activity was translated into structured spatial configurations in the spatial artifact record obtained. Without attempting to evaluate the _ceteris paribus_ propositions Binford (1976:342-350) makes for expedient and curated technologies, we have little recourse to information pertinent to this topic at HkPa 4. Nevertheless, the intensity of the spatial patterning of artifact types is a crude measure of expedience (Whallon 1973a:118).

2. Natural processes of disturbance have had a minimal effect upon horizontal artifact distribution.

Non-cultural processes have influenced the archaeological record at HkPa 4 by subtracting some elements of data and by modifying the spatial relationships of artifacts that do remain. Brunisolic and Podzolic soils are typically acid. Under such conditions, bone, wood, and other perishable artifacts are not preserved for any length of time. At the same time, processes of chemical weathering and translocation are particularly active and result in the light grey to white coloured Ae horizon. I feel that the texture and coloration of this eluvial horizon, in which the vast majority of artifacts occur, prevents consistent recognition of ash residues from hearths and thereby obscures the presence of an important feature of the archaeological record.

I visualize three factors contributing to the natural disturbance of spatial relationships between artifacts. The first, frost related activities, is difficult to access. Soils on the site are well drained. In some areas of the site, soils are marked by smooth horizon boundaries suggesting little frost heaving. Yet, other areas of the site (notably areas higher in clay content), some of which were excavated, display undulating Ae-Bm horizon boundaries, and frost heaving could be an explanation for this phenomenon. If frost heaving does occur, I suggest that it is important mainly in the vertical movement of artifacts.

The second factor involves displacement through root growth. Where young spruce stands are impenetrably dense, disturbance is expected. No excavation areas involved modern vegetation cover of this type. Since longitudinal root growth centres on the apical meristem, negligible longitudinal displacement is expected (Keeton 1967:606-607). Artifact disturbance would most likely by caused by circumferential root growth, and it is unlikely that this would disrupt culturally nonrandom artifact aggregates, although it is stratigraphically significant.

Finally, tree throw could transport artifacts some distance horizontally. Frequent tree throws generate a microrelief termed "mound and pit" topography. In profile, this is typified by rejuvenated soil horizons adjacent to buried soil horizons. No clear evidence of this type appeared during excavation. Spruce tree throws in the area have overturned root systems on the order of 1-2½ meters in diameter. On the basis of casual observation, no great quantity of soil appears to be uplifted, and presumably then, few artifacts. I would predict that shallow root systems would tend to pull right out of the sandy soil matrix at the site.

Roper (1976:374) points out that the lateral displacement of artifacts due to as vigorous an activity as plowing is not as great as is sometimes expected. It is my feeling that natural processes of disturbance have not significantly altered nonrandom horizontal artifact distributions at HkPa 4, and they probably do not contribute greatly to the natural formation of artifact clusters. The excavation of synchronic artifact aggregates in less densely occupied areas eliminates the problem of stratigraphic mixing. It is more difficult to control for disturbances where denser clusters of chronologically separated artifacts occur since overlap is more likely to take place. Further research into this difficult problem would be welcome, although avenues of theoretical exploration appear limited. In this regard, it should be noted that artifact disturbance, through human agency, roots, insects, or burrowing animals is a difficult problem on any site.

3. Episodes of human activity, including tool manufacture, use, and discard took place at spatially restricted loci at HkPa 4, and it is this feature which will be reflected in any significant spatial structure observed in artifact distributions.

The assumption of restricted areas in which human activity takes place is of the same type as that which Binford and Binford made with reference to Mousterian assemblages:

> The minimal social processes and organizational principles exhibited by human groups today were operative in the past (Binford and Binford 1966:291).

The claim that human activity has a measure of discreteness finds some confirmation in the early proxemics literature:

> The urge to occupy definite fields of activity is so obvious that we only notice it when it ceases (cf. Hediger 1955:19-20).

It is hypothesized, therefore, that the structuring of space on a microcultural level contributed to the archaeological record at HkPa 4.

4. Functional, cultural, and temporal differences existed between activities at these loci, and the nature of artifacts left behind at these loci can provide information about the activities that led to the deposition of the artifacts recovered:

    a). Spatial clusters of artifacts share systematic relationships with the processes that generated them.

Spatial clusters of artifacts are archaeological entities with specific attributes. These attributes may be defined on the basis of the artifacts present and include data such as frequencies for raw material, artifact class, and type of edge wear. Attributes may also relate to the spatial characteristics of the cluster, characteristics such as degree of dispersion or type of spatial patterning within the cluster. Such attributes allow us to speak of "types" of clusters, and permit speculation about formative processes. It is clear that clusters need not consist exclusively of "activity sets" from "activity areas".

    b). A consideration of finished artifacts is the most important step in assessing these underlying processes.

Unlike debitage, finished artifacts are related not simply to the technology of tool production, but to a variety of tasks. The relationship between finished artifacts and debitage is important, and will be explored; however, critical aspects of artifact use can be divorced from the earlier stage of manufacture. In treating spatial patterning, all finished artifacts are considered at once. Even if spatial clusters represented only expediently produced activit sets, more than one type of finished artifact would likely be involved.

    c). The presence of temporally sensitive items in spatial artifact clusters "tags" them chronologically.

The intent of this research design is to segment the data recovered from boreal forest sites on the basis of horizontal distributions. In a fashion, these segments can be viewed as synchronic building blocks of the artifact record on unstratified sites. This synchroneity cannot, of course, be proven. But, when corroborating archaeological evidence can be cited for the temporal relatedness (similar depth, same raw material, same use wear, logical sequence of use wear patterns, etc.) of artifacts, spatial association becomes more than coincidental and synchroneity is strongly suspected. When temporally sensitive artifacts such as projectile points occur in a cluster, it is reasonable to assign associated artifacts to a specific time range. If the sample were large enough, and if projectile points showed no strong correlation with other finished artifact types, it would be theoretically possible to identify temporally defined components on an unstratified site.

Analytical Framework

To operationalize this research design, it is useful to pose a series of four questions. The initial set is:

1. Are the distributions of artifacts in excavation units random?
2. If artifact distributions in excavation units are not random, how can we characterize these distributions?

It has been suggested that human activities in lithic artifact manufacture, use, and discard were not carried out at random and that artifact distributions will reflect this fact by exhibiting spatial structure. The application of statistical techniques originating in plant ecology and geography permits an objective evaluation of the significance of patterning in artifact distributions. At the same time, these techniques provide detailed and quantified descriptive statements about observed patterning. The initial demonstration of nonrandomness is essential. If an artifact distribution tests as random, then there is reason to believe that natural disturbance, cultural factors, or sampling design are responsible for the absence of significant patterning. A great many interpretations of the archaeological record become possible in such cases.

3. If artifact distributions are significantly patterned in the direction of aggregation (i.e., they are clustered or clumped), can spatially discrete artifact clusters be segregated?

Because finished artifact densities are low, because the horizontal modification of artifact distributions through natural processess is believed to be minimal, and because it is suspected that artifact discard took place at restricted loci, it should be possible to separate discrete spatial clusters on an objective basis. Taxometric procedures and methods derived from spatial analysis will be used in this regard.

4. If spatially discrete artifact clusters can be defined, are artifact types differentially associated in these clusters and are there cluster "types"?

The spatial clusters themselves can be submitted to taxonomic analysis in an effort to establish if different kinds of clusters exist as discernible types in the data. Using the spatial cluster as the unit of association, coefficients of similarity can be calculated for different artifact types to assess the degree of association between pairs of artifacts.

The success of this endeavour is limited by factors for which there are no apparent solutions. The vertical movement of one or a few isolated artifacts, might ultimately result in the false association of some chronologically separated specimens within a single cluster. Sample unit size could also influence results; the sample unit must be larger than the scale of patterning anticipated or spatial analysis will reflect only the nature of the distribution within a nonrandom aggregate.

Lastly, there are myriad microgeographical differences within a site, such as variable wind, soil, vegetation, and drainage conditions, which lead to differential use of areas. The same features may also limit overall site utilization. As a result, there will be areas with different artifact densities. At those locations on the site where numerous artifacts are discarded, and these areas need not be so much task oriented as manufacturing oriented, the possibility of cluster overlap arises. Overlap may be synchronic or diachronic in nature. Even if it is diachronic, the lack of stratigraphy prevents objective distinction between temporally separated clusters. Under these circumstances, cluster definition is misleading unless there is a clear understanding of the rather severe constraints involved. At the opposite extreme, an "activity area" can be represented by a single artifact. Yet, single artifact activity areas are hardly suitable for statistical analysis. In the following discussion, analysis is not continued when these complications are suspected. Consequently, only a portion of the data recovered can be subjected to rigorous study.

CHAPTER II.

NATURAL SETTING OF THE BIRCH MOUNTAIN AREA

Site Description

HkPa 4 is located in the Birch Mountain Uplands of northeastern Alberta and is situated on the north side of the confluence of drainages from Eaglenest and Clear Lakes (see Figure 1). The site is fairly well elevated, being situated on a terrace approximately 7 meters above a small stream. The locale is well drained, but grades to boggy conditions on either side and towards the back of the terrace. HkPa 4 is extensive horizontally and testing during the two years of field work completed suggests dimensions on the order of 100 by 250 meters. The long axis of the site extends along a shallow, narrow, and rocky stream continuing from the southeasterly arm of Eaglenest Lake (see Figure 3).

Climatic Conditions and Physiography

The Birch Mountains, rising some 525 meters above the surrounding lowlands, constitute the remnants of Late Tertiary Plains in this province and are underlain by poorly consolidated Late Cretaceous slates and sandstones (Bayrock 1961:49-51). Eskers, kames, outwash plains, and ground moraine are common throughout the area. Glacial fluting and hummocky disintegration moraine typify terrain in the vicinity of the site. Ridges tangential to glacial fluting may derive from underlying bedrock, the site being located on one of these features. Bayrock (op. cit.) characterizes recent tills in the area as brown, clayey, and non-calcareous.

Van Waas (1974:4) has designated two major physiographic regions: the Birch Mountain Upland Plains, and the Central Birch Mountain Depression. The major lakes in the area, including Eaglenest, Clear,

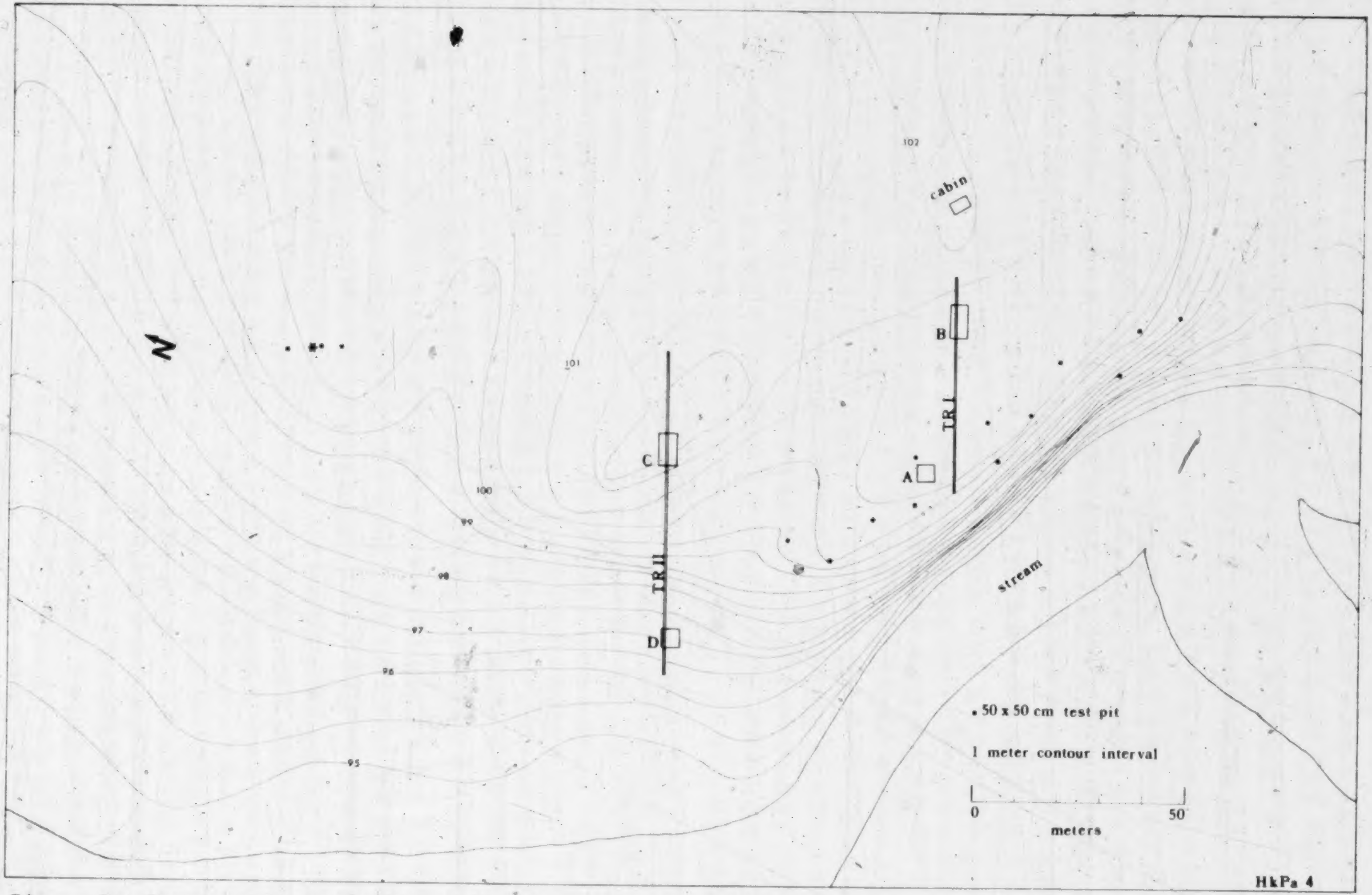

N
102
cabin
101
100
99
98
97
96
95
A
B
C
D
TR I
TR II
stream
• 50 x 50 cm test pit
1 meter contour interval
0
50
meters
HkPa 4

Figure 3. Topographic map of HkPa 4 showing test pits, 4 by 4 and 4 by 8 excavation blocks (A-D), and Transects I and II. The asterisk denotes site datum.

Sandy, Big Island, Gardiner, and Namur, are located within this Depression. It is drained to the South by the Ells River and to the northeast by creeks which eventually join the Birch River. The Central Birch Mountian Depression is marked by gently to moderately rolling complex topography.

The area lies within Longley's (1967:67) short cool summer climatic subzone. Van Waas (1974:6) reports approximately 23 centimeters of rainfall for the May to September period in the northeastern area of the Birch Mountains. Killing frosts occur well into the month of June and the frost-free period is generally less than 60 days. Apparently the large lakes in the Central Depression effect a slight climatic amelioration.

Soils

Grey Luvisols predominate over the majority of the region, although an estimated 30% of the area is covered by organic soils underlain by permafrost (Lindsay et al 1961:37). Drainage on the site itself is good and soils are sandy in texture. The soils on the elevated portion of the site are almost exclusively Eluviated Dystric Brunisols having LFH, Ae, and Bm or Btj horizons (Agriculture Canada 1976:44). In some areas of the site, particularly areas with heavy ericad moss-lichen cover, soils border on the Podzolic Order. Depressional areas surround the site on either side and here are found Rego Gleysols or Luvic Gleysols (Agriculture Canada 1976:68-69). Typical soil horizons are presented in Figure 4.

Brunisolic to incipient podzolic conditions in soils at the site have two ramifications. First, processes of chemical weathering and translocation make for rather poor preservation. As a consequence,

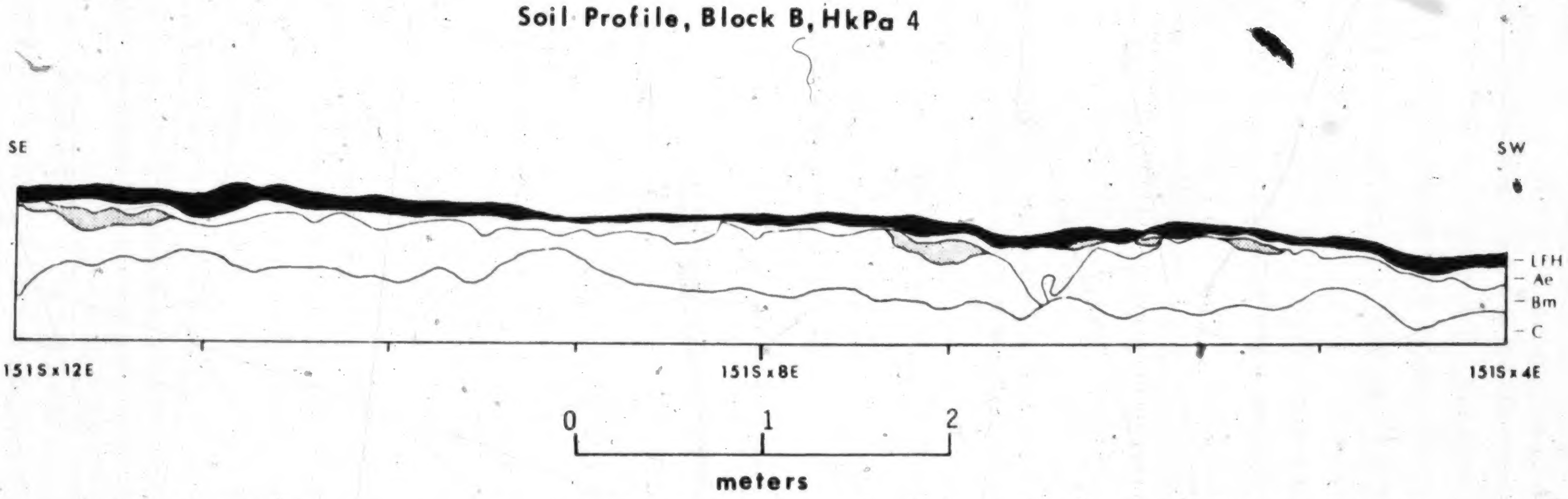

Soil Profile, Block B, HkPa 4
SE
SW
LFH
Ae
Bm
C
151S x 12E
151S x 8E
151S x 4E
0
1
2
meters

Figure 4. South wall of meter squares 18, 22, 26, 30, 34, 38, 42, and 46, Block B. This profile is typical of the brunisolic soils on the site. Dotted areas represent lenses of tan-coloured sands of unknown origin.

faunal remains at the site are very rare indeed. Second, the presence of a moderately well developed Ae horizon resulting from eluviation makes it impossible, in my opinion, to speak of ash residues from a hearth.

Flora

The Birch Mountains fall within the mixedwood section (B. 18a) of the boreal forest (Rowe 1972:36). The characteristic forest association of the well drained uplands includes trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), white birch (*Betula papyrifera*), white spruce (*Picea glauca*), and balsam fir (*Abies balsamea*). Jack pine (*Pinus banksiana*) is dominant on sandy areas, enters into forest composition on drier tills, and mixes with black spruce (*Picea mariana*) on higher hills. Poorly drained locations develop black spruce and tamarack (*Larix laricina*) muskeg (*ibid*).

White spruce (*Picea glauca*) predominates on the site itself, especially in frontal (water's edge) areas of the terrace. Jack pine or aspen are more common 20-30 meters farther back. A depressional area on the site is dominated by *Betula glandulosa* and young black spruce. Both species, along with *Ledum groenlandicum*, are common in low, boggy areas at either side of the site. Ground cover consists largely of mosses and lichens, although ericads such as *Vaccinium vitis-idaea*, *V. myrtilloides*, and *V. uliginosum* can be numerous. The grassy embankment on the southeastern portion of the site supports various species of *Compositae* (such as *Soldago multiradiata* and *Achillea millefolium*), *Rosaceae* (*Rosa woodsii* and *Rubus strigosus*), as well as species such as *Cornus canadensis* and *Epilobium latifolium*.

Fauna

The Birch Mountains area supports a diverse mammalian fauna including black bear (*Ursus americanus*), timber wolf (*Canis lupus*), lynx (*Lynx canadensis*), varying hare (*Lepus americanus*), beaver (*Castor canadensis*), mule deer (*Odocoileus hemionus*), woodland caribou (*Rangifer tarandus sylvestris*), and the woods bison x plains bison hybrid (*Bison bison bison* x *Bison bison athabascae*) (Allison 1973a:D1-D4; Soper 1967:35-36).

Study indicates that the Fort McMurray region is not a heavily used waterfowl migration route in the autumn, and it is likely that the area is not important as a staging or resting point (Syncrude Canada Limited 1973:19). Among the several species of fish which naturally invaded the area with deglaciation are lake whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), Arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), and walleye (*Stizostedion vitreum vitreum*) (Paetz 1973:B1-B2).

Paleoenvironment

Bayrock (1961:49-50) speculates that the Birch Mountains became exposed as a nunatak during the final retreat of Wisconsin ice. However, a single radiocarbon date of 8600 ± 100 B.P. (S-116) obtained from peat in contact with glacial till (denoting first vegetative growth) in the Caribou Mountains raises the possibility that a combination of latitude and elevation may have resulted in much later deglaciation (McCallum and Wittenberg 1962:74). Resolution of this problem has obvious implications for the antiquity of human occupation in these uplands.

With recession, Glacial Lake Tyrell formed (Taylor 1960:173-175). It flanked the Birch Mountains along the present day Peace River valley to the North and along the Athabasca River valley to the South and East.

There remains little work in the area concerning the reconstruction of past environments. Lichti-Fedorovich (1970) analyzed a section of limnic sediment from Lofty Lake, Alberta, also within the mixedwood section of the boreal forest. The basal organic sediment was radiocarbon dated at 11400 ± 190 years, and Mount Mazama ash is noted. She reports five pollen assemblage zones beginning with a late Pleistocene *Populus-Salix-Sheperdia-Artemisia* assemblage. This is equated with a pioneer forest and shrub community occupying the area following deglaciation and is succeeded by a *Picea* assemblage believed to represent a pioneer boreal forest. It is followed by a tree birch dominated assemblage with some poplar and hazel. Slight climatic amelioration continued to about 6000 B.P. when a birch-alder-shrub assemblage reached a maximum. A spruce-birch-alder assemblage followed and continued through to the present. Similar results are reported from Alpen Siding Lake, Alberta (Lichti-Fedorovich 1972). While there is some doubt about the heuristic utility of these assemblages, it does seem clear that the modern composition of the boreal forest vegetation, the mixedwood section, has been established since about 3500 B.P. (cf. Lichti-Fedorovich 1970).

CHAPTER III.

MAN-LAND RELATIONSHIPS AND THE UTILIZATION OF HkPa 4

Ethnohistory

Archaeological research in northeastern Alberta has not yet reached a stage allowing the implementation of Steward's (1942:337) three phase direct historical approach to archaeological data. However, HkPa 4 is the richest site on the Eaglenest-Clear Lake drainage system, and is the only site in the vicinity on which historic cabins were located. Moreover, as will be seen (Chapter IV), the great majority of diagnostic items (in particular, side and corner-notched projectile points equated with ca. A.D. 800 to A.D. 1750 Late Taltheilei specimens) indicate occupation during more recent periods. It is reasonable, therefore, to attach some significance to the historic inhabitants of the study area, the Beaver Indians.

Jenness (1963:382-384) indicated that at about the middle of the eighteenth century, the Beaver Indians occupied the entire basin of the Peace River below its junction with the Smokey. This included the district around Lake Claire and the valley of the Athabasca as far south as the Clearwater and Methy Portage. Morice (1905:190) regarded the Beaver, or Tsattine ('dwellers among the beavers'), as a subdivision of the Sekani group (Hodge 1910:822).

The Cree were the major non-Athapaskan group influencing the Beaver prior to contact. In proto-historic and historic times, they made significant inroads into Beaver territory (Bryan 1969:37). Before 1760, the Cree acquired firearms through the fur trade first and swept the Beaver from the valley of the Athabasca, confining them to the basin of the Peace (Jenness _op_. _cit_.). According to MacKenzie (Lamb 1970:250) this caused the western Beaver to begin to displace the Sekani towards the Rocky Mountains. The Slave of Lower Hay River and Upper Liard River were neighbours to the North while the Chipewyan of Lake Athabasca were to the East.

A consideration of Beaver ethnohistory provides useful archaeological insights by suggesting avenues of external influence. The Beaver appear to have stood in close relationship to the Sekani, and Harmon (1911) proposed that

> The people who are now called the Si-can-nies I suspect, at no distant period, belonged to the tribe, called Beaver Indians, who inhabit the lower part of Peace River; where they differ but little from them in dialect, manners, customs, &c. Some misunderstanding between the Sicannies and the rest of the tribe to which they formerly belonged, probably drove them from place to place, up Peace River, until they were at length, obliged to cross the Rocky Mountain (Harmon 1911:265).

Similarly, the more southerly Sarcee seem to be fairly closely related to the Beaver despite their position in the Blackfoot confederacy. The Sarcee speak an Athabaskan dialect closely akin to the Beaver, and both groups have myths pertaining to their separation (Goddard 1916:209).

Donahue (1975:13) argues for prehistoric interaction on an East-West axis across the Rockies, and Beaver-Sekani proximity constitutes an historical analogue for relationships. Prehistoric contact with British Columbia is further confirmed by a small flake of obsidian from northwestern British Columbia found at Pitchimi Lake, in the Caribou Mountains (Donahue 1976:viii). A small flake of welded tuff from HkPa 4 has also been positively identified, and suggests more northerly contact. The nearest known source would be Keele River, N.W.T. (Cinq-Mars 1973; Donahue 1976:63). Thus, while it is reasonable to assume that the Beaver Indians are likely the immediate prehistoric occupants of the study area, the dynamic nature of historic and proto-historic interaction with groups such as the Cree and Sekani argues against extending this hypothesis to any great time depth.

Man-Land Relationships

Beaver cultural ecology remains enigmatic. In the account Goddard (1916) provides, the hare was an important food resource. They were often snared by women. Small game species such as the hare are susceptible to population crashes, a factor which would periodically eliminate them as a food resource (Odum 1971:188-195). Goddard (1916:214) notes such declines in local hare populations. The beaver provided a somewhat more dependable food resource of almost equal importance. Poles were placed across the entrance of the lodge, which was opened from above.

When Mackenzie first journeyed up the Peace River, he noted large herds of bison and elk on nearby plains (ibid.). Apparently bison were hunted solely on a community basis. The importance of bison to the Beaver Indians is unclear, and Goddard (ibid.) reports that "...the tipi in former days was made of skins of the caribou or moose". There is no mention of the use of buffalo skins for this purpose, as on the Plains (ibid.). Caribou were shot while swimming and may have been impounded on frozen lakes. Bears were numerous. It was the moose, however, which was the most esteemed game, and Goddard (1916:215) discusses at length the evenly matched contest between moose and hunter.

No details of a seasonal round are suggested by Goddard, although some scheduling in resource exploitation is to be expected (see next section). Bands are known to have resorted to fish lakes when game failed (ibid.:216). Goddard (ibid.) relates that fish lakes were numerous South and East of the Vermilion area of the Peace River while many lakes and sloughs in the country North and West of the Peace River had no edible fish. Spawns were exploited by weir building:

> In the spring when certain varieties of fish were migrating, walls of stone were built out from each shore of the smaller streams converging in the centre where a trap was placed made of poles placed lengthwise of the stream. The water falling between the poles left the fish helpless (ibid.).

Seasonality in the Occupation of HkPa 4

At the outset, it must be made clear that there is no conclusive evidence for a strictly seasonal occupation of HkPa 4. Nevertheless, the topic of seasonality can be explored in two different fashions: reconstruction of a plausible seasonal round based on modern ecological evidences and extrapolation from the limited evidence at the site provided by lithic raw materials and the absence of hearths or firepits.

Surveys by Donahue and Sims indicate some correlation between annual fish productivity of lakes in the Central Birch Mountain Depression and the number and richness of sites on those bodies of water (Donahue 1976: 115; Sims 1977:pers. comm.). A preliminary biological survey by the Alberta Fish and Wildlife Division indicates that Gardiner Lake has a fish productivity of 30,000 pounds per year, Big Island Lake a productivity of 18,500 pounds, and Sandy Lake 8,750 pounds per year (Turner 1968: 69,100,122). Unfortunately, this survey did not reach Eaglenest Lake. Sims (pers. comm.) has located a very rich site at the narrows of Gardiner Lake (HjPd 1), and Donahue (1976:113) located ten other sites on North Gardiner Lake. One of these, HjPc 14, is sufficiently rich to merit further attention. Sixteen sites were discovered on Big Island Lake, and one of these, HjPc 4, is also a rich site (ibid.). In contrast, Sandy Lake had only eight archaeologically poor sites (ibid.). Donahue's 1975 survey indicated a high density (fifteen sites located) on the Eaglenest Lake - Clear Lake drainage system, three of these being quite rich. Eaglenest and Clear Lakes were two of the smallest lakes examined in the course of that survey, yet site density was highest there. Thus, it is not unreasonable to speculate that Eaglenest and Clear Lakes are now or were at one time quite productive, and that site location may have some special reference to the exploitation of fish resources.

Could the exploitation of a fish resource be seasonal in nature? Beaver Indians were known to resort to fish lakes during the winter in times of hardship (Goddard 1916:216). Both lake whitefish and lake trout spawn in shallow lake waters during the fall, and this fact could provide some seasonal orientation for the occupation of HkPa 4 (Scott and Crossman 1971:222-223,271). However, the location of the site on a narrow rocky stream between Eaglenest and Clear Lakes argues for an alternative possibility. Spring runs of northern pike, greyling, and walleye, could be effectively exploited by weir building at this location (Scott and Crossman 1971:302-303,357-359,770-771). Since late winter and early spring can be regarded as a critical subsistence time for boreal forest peoples, the occupation of HkPa 4 might be closely related to the exploitation of spring fish runs.

Donahue (1976:128) has demonstrated the differential utilization of the Birch Mountain and Caribou Mountain Uplands, in that the greater density of sites in the former area can be attributed to a more favourable habitat. Woods bison represent an important additional element in the prehistoric big game population. While bison do not appear to have ranged into the Caribou Mountains, Soper (1941:363,365) regards the Thickwood-Birch Mountains sector as an earlier centre of abundance where a small number of bison survived extinction during the period of extreme herd and range reduction in the last century. It is likely that a slightly more diverse large mammal community and a greater abundance of big game species contributed to the more intense prehistoric utilization of the Birch Mountain Uplands.

In the context of an upland, local seasonal movements of big game species become influential in human adaptive strategies. Soper (1967:48) comments that bison, woodland caribou, and wapiti descend from highlands for the winter. He has recognized two distinct seasonal movements of woods bison in Wood Buffalo National Park (Soper 1941:384). With the onset of winter, bison move out of uplands to lowland grazing areas. Herd size increases at this time. With spring, herds move back into the uplands, gradually dispersing as they go. Allison (1973b:M21) indicates a somewhat more complex pattern of herd aggregation and dispersion during movement between summer and winter ranges, although a tendency toward larger herds in winter than in summer north of the Peace River is recognized. Preliminary evidence for the Birch Mountains indicates that moose also leave these uplands during the winter, although woodland caribou do not (Hauge 1977:pers. comm.). It appears that the big game resource on the uplands would thus be maximized in the summer and restricted during the winter. An early spring occupation initially directed at the exploitation of fish spawns could mark the beginning of a big game hunting summer phase of a seasonal round.

The presence of Beaver Creek Quarry quartzite of HkPa 4 could provide critical information for the evaluation of seasonality. The Beaver Creek Site is located in the Athabasca Valley, near Fort McKay (Syncrude Canada Limited 1974). Unfortunately, there appears to be no information regarding the seasonal occupation of that site. If we could rule out the possibility of recovering nodules of Beaver Creek Quarry quartzite during the winter (due to snowfall), it would be hypothetically possible to link the occupation of HkPa 4 to spring or summer periods. This is not a strong argument, however. The Beaver Creek Quarry is located on an embankment, and it is entirely possible that winter snowfalls would not effectively cover it for some period of the winter. In addition, Sims (pers. comm.) informs me that bluffs on the opposite shore of the Athabasca exhibit vertical faces of Beaver Creek Quarry quartzite which (presumably) would be available year round.

In summary, site location and effective resource utilization argue for occupation beginning with spring fish runs. Occupation based on the exploitation of larger ungulates could extend into the summer. At the same time, the high density of sites on the Eaglenest-Clear Lake drainage may be related to their utilization as fish lakes during the winter. In either case, an emphasis on the exploitation of a fish resource seems most likely in the absence of concrete faunal evidence.

CHAPTER IV.

SITE EXCAVATION, ARTIFACT DESCRIPTION, AND TEMPORAL-REGIONAL RELATIONSHIPS

Excavation Procedures

During the ten week field season and for a brief period in September, the four person crew opened the equivalent of 128 square meters. Two transects, 25 centimeters in width, and running back from the water's edge, were excavated. Generally, individuals worked on four meter segments of a transect. All artifact coordinates were recorded then so that further excavation over a transect would not leave a gap. Two 4 by 4 meter units (Blocks A and D) and two 4 by 8 meter units (Blocks B and C) represent the bulk of the excavated area. Usually these were quartered, with individuals each excavating a quadrant. This allowed a preliminary assessment of spatial patterning in the field.

Hand trowels, grapefruit knives, and brushes were employed. Caution was exercised in excavation and backdirt was not screened. The overwhelming majority of artifacts were found in the Ae horizon (see Figure 4), within 10 to 15 centimeters of the ground surface. Every effort was made to follow microtopography and natural soil horizons in a sequence of levels within a square since arbitrary levels would distort the spatial relationship between artifacts. Because artifacts occur so near to the surface, depth is affected markedly by microrelief. For this reason, below datum measurements are not an absolute guide in efforts to define spatial clusters described in Chapter VIII. This drawback could be overcome by making small topographic maps of microrelief within squares. However, interpreting the results of this procedure would remain complicated, the additional information is misleading in terms of accuracy, and the method is time consuming. Because research design emphasized horizontal distinctions between artifacts, it was not adopted. Excavation proceeded to 35-40 centimeters below surface (with occasional deeper test pits), at which depth the excavation unit was levelled.

The types of spatial analysis applied required the recording of coordinates for all artifacts, save small retouch flakes. These were recorded by level or by concentration within a level. Records were kept for individual meter squares within the block units. Small plastic coin bags were used to bag each artifact separately. Every artifact recovered (excluding retouch flakes) can be associated with the exact coordinates it was assigned.

Features and Radiocarbon Assay

Two of the three features recognized during excavation at HkPa 4 are now regarded as natural phenomena of little archaeological consequence. The third, Feature #3, consists of an irregularly shaped segment of buried soil horizon extending over the East central area of Block C. A horizon sequence of LFH, tan coloured sand (probably representing a mixture of several soil horizons), buried organic horizon, Aeb, and Bmb-Btjb horizons was noted. The buried Ae horizon dipped as low as 20 centimeters below surface and in areas about Feature #3, rose up to meet the surrounding Ae horizon. The buried Ae horizon was a rosy hue which may be associated with intense heating. While it is conceivable that this feature might represent an isolated segment of living floor, it more likely resulted from a forest fire with subsequent sand filling of a microtopographic depression.

Localized concentrations of charcoal flecks and lumps occurred on the surface of the buried organic horizon, and these were sampled individually for radiocarbon assay. It proved necessary to analyze only one of these samples (thereby avoiding any admixture); 5.5 grams of charcoal from Square 67 provided a date of 1030 ± 110 years B.P. (DIC-720, Irene Stehli, pers. comm.). Following the correction table of Damon et. al. (1974), interpolated dates (rounded to the nearest decade) of 1020 ± 165 years B.P. or A.D. 930 ± 165 years are obtained.

The small sample size warrants caution in the interpretation of this date. Furthermore, despite two laboratory microscopic pretreatments, root hairs remain a source of possible contamination. These, however, would cause error in the direction of recentness. Therefore, A.D. 930 is regarded as the minimum possible date for artifacts associated with Feature #3. Two side-notched projectile points were recovered from the surface of the buried organic horizon.

Artifact Description

A total of 6,721 artifacts were recovered during the 1976 excavations at HkPa 4. The assemblage was dominated by debitage, including bifacial thinning flakes, shatter, decortification flakes, and retouch flakes. Of the total assemblage, 300 artifacts were termed "finished artifacts". These are broadly defined as artifacts that have been modified by flaking and retouch, or through use wear. Finished artifacts are subdivided into gross morphologically or technologically defined categories. Cores and split pebbles were included as finished artifacts in order to permit an unbiased consideration of technological as well as stylistic and functional variables in spatial analysis. A more detailed description of artifacts from HkPa 4 has already been made (Ives 1977), to which the reader is referred.

Lithics

Raw lithic materials at HkPa 4 were dominated by quartzites, with lesser percentages of cherts, quartz, argillite, and sandstone. For a spatial analysis, a finer breakdown of lithic types seemed desirable (see Table 1). Petrographically variable characteristics such as colour or inclusions can serve as important archaeological guides in relating individual specimens to a particular technological event.

TABLE 1

FREQUENCY OF LITHIC CLASSES AT HkPa 4

Material	Number of Artifacts	%
1. Quartzite	4681	69.6
2. Beaver Creek Quarry Quartzite	300	4.5
3. Black Chert	191	2.8
4. Argillite	40	0.6
5. Other Chert	402	6.0
6. Quartz	116	1.7
7. Salt and Pepper Quartzite	55	0.8
8. Heat Treated Quartzite	708	10.5
9. Heat Treated Salt and Pepper Quartzite	82	1.2
10. Sandstone	37	0.6
11. Low Grade Quartzite	55	0.8

Heat treatment can also serve to isolate related items of flaking debris, although the inclusion of this category is not meant to imply detailed experimentation. However, the heating of clear light and dark grey quartzites in an open firepit resulted in demonstrable changes. Heating in red hot coals for a few minutes resulted in opacity. Prolonged heating caused clear siliceous grains to appear in an off-white matrix. Flakes treated in this manner appear to be more brittle. The lustre and colouration of several chert specimens also suggested some degree of heating. It should be borne in mind that forest fires might cause a significant percentage of heat altered lithics.

Quartzite refers to the very common clear light and dark grey quartzites found throughout northern Alberta. "Salt and pepper" quartzite is virtually identical, except for the inclusion of numerous dark flecks (possibly black chert). Low grade quartzite refers to coarse, less intensely metamorphosed quartzites most frequently seen in cobble tools and spalls. As Donahue (1976:111) points out, the presence of black chert in northern Alberta is often associated with the Peace River area. However, black chert nodules are present in local tills. Beaver Creek Quarry quartzite is presently known only from the Beaver Creek Quarry Site in the Athabasca River Valley. One small specimen of welded tuff was recovered during the 1975 test excavations at HkPa 4. The nearest known source would be Keele River, N.W.T. (Donahue 1976:63). Finally, one fragment of obsidian was surface collected at HkPa 4 during the 1976 field season. Results of a source analysis are not yet available. A specimen of obsidian collected at Pitchimi Lake, Caribou Mountains apparently comes from northwestern British Columbia (Donahue 1976:viii).

Core rejuvenation flakes, decortification flakes, retouch flakes, bifacial thinning flakes. fragments or shatter, and a general category of flakes are recognized in the debitage. Finished artifacts are separated into fourteen categories. Lanceolate, stemmed, side-notched, corner-notched, and basally flared projectile points are represented in the assemblage. There are 19 reasonably complete projectile points, although several tips and bases were discovered during the two years of fieldwork.

Thirteen larger bifaces are noted, although most of these are fragmentary. All exhibit some degree of edge sinuosity with variable degrees of finer retouch.

Unifaces are well represented in the assemblage. These include 49 endscrapers, 7 sidescrapers, and 4 much larger unifaces. Spurred, flake, pebble, and rectanguloid endscrapers are present. In general, edge angles are rather high, and no specimen has a distal working edge angle of less than 45 degrees. Sidescrapers have consistent retouch which creates a bevelled effect over a relatively lengthy edge. Although extensive analysis has not been undertaken, microscopic edge analysis suggests that some specimens have been used in "hard" working (i.e., bone or wood), others in "soft" working (e.g., hides), while some may have been unused (John Brink, pers. comm., based upon ongoing experimentation; personal observation).

Retouched and utilized flakes account for 60% of the finished artifacts recovered at HkPa 4. The 95 retouched flakes have been classed according to edge form: convex, straight, concave, irregular. Over 65% of these were manufactured on quartzite flakes, with black chert (at 12%) being the next most popular raw material. Several specimens are rather large (over 50 millimeters in length), have pronounced edge wear, and rounded polished dorsal ridges. Utilized flakes exhibited only slight, irregular and discontinuous marginal retouch thought to have been unintentional in nature, or, evidenced either macroscopic or microscopic signs of abrasion and rounding. Comparatively extensive use wear was not uncommon among utilized flakes as well. Quartzite and black chert again dominated raw materials.

Fourteen cores were recovered and these range from virtually unaltered specimens to exhausted cores. Amorphous, multidirectional discoidal, and angular unidirectional cores and core fragments are present. Split pebbles lack evidence of bipolar percussion and appear to have been split or had flakes detached by an oblique blow. Three specimens are placed in this category. Bipolar split pebbles (18 specimens) and debitage probably resulting from pebble splitting are fairly common, as are unifaces fashioned on split chert pebbles and retouched flakes made on chert decortification flakes. Bipolar split pebbles are marked by heavy battering and crushing at either end, flake scars at opposite ends of the specimen, double bulbs of percussion and heavy rings of percussion. Other finished artifacts included three hammerstones, six large cobble tools, and seven spall tools. The latter are chi-tho like implements.

Faunal remains are particularly rare at HkPa 4 and this can likely be attributed to poor conditions of preservation. Tiny fragments of burnt bone were recovered in Blocks A and B and somewhat larger fragments of bone occurred in Blocks A and C. Unfortunately, remains were too fragmentary to permit precise identifications. Scapular and ulnar bone fragments in Block C are either moose or elk. Four specimens exhibit rounded, bevelled edges and have been classed as bone tools. Several bone fragments appear to have been cut.

There are two cabins at HkPa 4 and several historic artifacts were recovered. These included a button, buckle, clinched round-headed nails, rifle shells, a repeating rifle lever, seed beads, miscellaneous bits of glass, and tin can fragments. Historic artifacts were not used in spatial analysis because they all appear to be comparatively recent. The rifle lever was located in Block B while the remainder of the historic artifacts were restricted to Block A.

Regional and Temporal Relationships

HkPa 4 seems to have been occupied over the last two millenia. A ground lanceolate projectile point can be compared with Middle Taltheilei specimens. Gordon (1976:13) suggests a time range from A.D. 150 to A.D. 600 for similar specimens. Small stemmed projectile points from HkPa 4 are similar to specimens from Fisherman Lake and the central District of Mackenzie. Noble (1971:112) dates stemmed Windy Point Complex specimens at A.D. 300-500, while Millar's (1968) Mackenzie Complex is dated at ca. 300 B.C. to A.D. 500. One basally flared projectile point is tentatively compared with a Karpinsky Site specimen, although that assemblage is distinctive and is marked by much larger bifaces. It is dated at A.D. 880 (Bryan and Conaty 1975:68). Two small side-notched points were directly associated with Feature #3, dated at A.D. 930 ± 165. This is a reasonable date for Late Taltheilei side and corner-notched points; Gordon (1976:17) suggests dates from A.D. 800 - A.D. 1750 for Late Thaltheilei. Small side-notched points are also reported in the Spence River Complex (Millar 1968; Fedirchuk 1970). Finally, four specimens are reminiscent of the Frank Channel Complex. Noble (1971:114) dates this at A.D. 1300-1500.

The best formal comparisons for HkPa 4 materials lie with the Lake Athabasca area, the central District of Mackenzie, and the Fisherman Lake areas. Considerable emphasis has been placed upon the admixture of characteristically Plains as opposed to Boreal Forest related artifacts in northern Alberta prehistory. While specific Plains influences may be substantiated ultimately, present evidence for this is not convincing (Ives 1977). For the purposes of spatial analysis, HkPa 4 has been occupied for at least the last 2000 years, and artifact distributions are clearly not related to a single synchronic component. It is possible that groups with different cultural affiliations--Plains or Boreal Forest--utilized the site contemporaneously or at different points in time, although this problem remains enigmatic.

CHAPTER V.

SAMPLING STRATEGY

Archaeological Sampling

Sampling is a compromise between acquiring an adequate representation of a sampling universe and not having to deal with that body in its entirety. To gain the most accurate idea of the properties of a site (as a sampling universe), it should be excavated completely. As in the present case, however, practical limitations in time and financial expenditure often make this impossible. Thus, the investigator must determine the kind of data he wishes to recover and account for the adequacy of proposed recovery procedures with regard to project goals.

The major thrust in recent archaeological sampling has involved randomizing, probabilistic techniques (cf. Binford 1964; Ragir 1967). The value of probabilistic sampling designs lies in the resulting dispersal of small (such as one meter square) sampling units. This increases the chance of discovering the range of variability characteristic of the artifacts at a site. Randomly chosen samples permit statistically objective estimates for densities of artifact populations per unit surface area or volume, size of artifact populations, ratios of frequencies between items, percentages of subclasses and types, means and distributions of metric attributes and so on (Asch 1975:181). To obtain a reliable sample which can be used for estimates of this type a realistic sample size must be set. The sheer enormity of HkPa 4 (something on the order of 25,000 square meters) precluded attaining objectives of this type. Actual sampling intensity was well below one percent.

Sampling Requirements in Spatial Analysis

In addition, concern for the spatial structure of artifact distributions introduces further difficulties in sampling. Asch (1975:172) is correct in suggesting that the adequacy of a sample of cultural materials is related not only to the items themselves, but to populations of spatial relationships *between* the items as well. The observation of spatial structure requires large scale excavation units. When probabilistic selection procedures are followed in locating these large units, enormous standard errors in population estimates result since so few can be completed (Asch 1975:185). Most pertinent to this study, the greater the degree of contagion or aggregation which exists in the target population, the greater sample error becomes. Obviously, the aims of probabilistic sampling strategies (concerned primarily with accurate population parameter estimates) conflict with the requirements of spatial analysis (concerned primarily with spatial relationships between artifacts), unless a rather large scale project is envisaged.

If such a project were possible, HkPa 4 could be stratified into a sequence of lengthy bands extending back from the stream on which it is situated. Large excavation blocks, at a more satisfactory sampling intensity (5-10%), could be randomly placed within each band. This would be potentially informative in that environmentally correlated strata could be randomly sampled and results compared. However, the large units required for spatial analysis and the low sampling intensity (resulting from practical contingencies) made probabilistic sampling impractical.

Despite the recent emphasis on probabilistic sampling in archaeology, nonprobabilistic procedures remain important. Nonprobabilistic procedures offered two related advantages in this case. First, it remained desirable to make the sample recovered as representative as possible of both artifact types and artifact spatial organization at HkPa 4. It can be seen that if a mere four sample units were placed randomly at the site, the sample obtained might very well provide a poor picture of actual conditions. Instead, my intent was to make the small number of sampling units as broadly inclusive of the range of conditions as possible. This purposive strategy involved a second advantage, that of archaeological judgement. Experienced statisticians seem to agree that professional judgement is probably a better alternative to an extremely small random sample (cf. Asch 1975:185). Exercising archaeological judgement permitted the placement of excavation blocks in areas with predetermined characteristics. These characteristics included different artifact densities, different ratios of finished artifacts, and different locations on the site. Locations were selected with the aid of transects. Transects can provide data concerning distribution, density, and sequencing from reference points (such as water's edge) of artifact concentrations. In terms of an archaeological site, since a transect plot will crosscut more areas of a site than a quadrat of equal size, it yields more information about the spectrum of conditions at the site.

The sampling strategy used is statistically biased. For example, an estimate of the number of artifacts on the site from the sample obtained would not be probabilistically valid. In spite of this, nonprobabilistic procedures were followed because they allowed for archaeological judgement in acquiring a potentially more representative sample than might be the case with a small random sample. At the same time, this allowed an active interplay in the field between the data recovered and sampling design. In summary, this was accomplished by:

1. Locating sampling units in areas where known artifact concentrations have been ascertained, thereby
2. Selecting more representative, if biased, samples when only a low percentage of units can be excavated, and at the same time,
3. Increasing the collecting efficiency for rare items(cf. the scheme suggested by Asch 1975:191).

This strategy served the dual purpose of collecting adequate baseline data within a framework suitable for spatial analysis.

To reiterate, the emphasis in sampling design is not on randomizing techniques permitting the evaluation of artifact population parameters on the site, but on nonprobabilistic sampling with a view to the analysis of the spatial relationships existing between artifacts and artifact aggregates. In considering the results of spatial analysis presented later, the reader must bear in mind that sampling intensity was low and that sampling units were not positioned randomly. Nevertheless, it is hoped that the methods described below and the decisions made in positioning excavation units provide a representative picture of the spatial organization of artifact distributions at HkPa 4.

Sample Units

A two phase excavation strategy was implemented. Transects were used in an effort to locate artifact concentrations. Transect I was 50 meters in length, while Transect II was 76 meters in length. Time has not permitted the consideration of all the types of data recovered from the two transects completed. However, transects are an efficient means of assessing site extent and content while indicating areas with high potential for excavation. Their use as a predictive tool deserves more attention from archaeologists. As pointed out already, recording artifact coordinates within transects allows larger units to overlap transects without consequent loss of data. Figure 5 shows the portions of

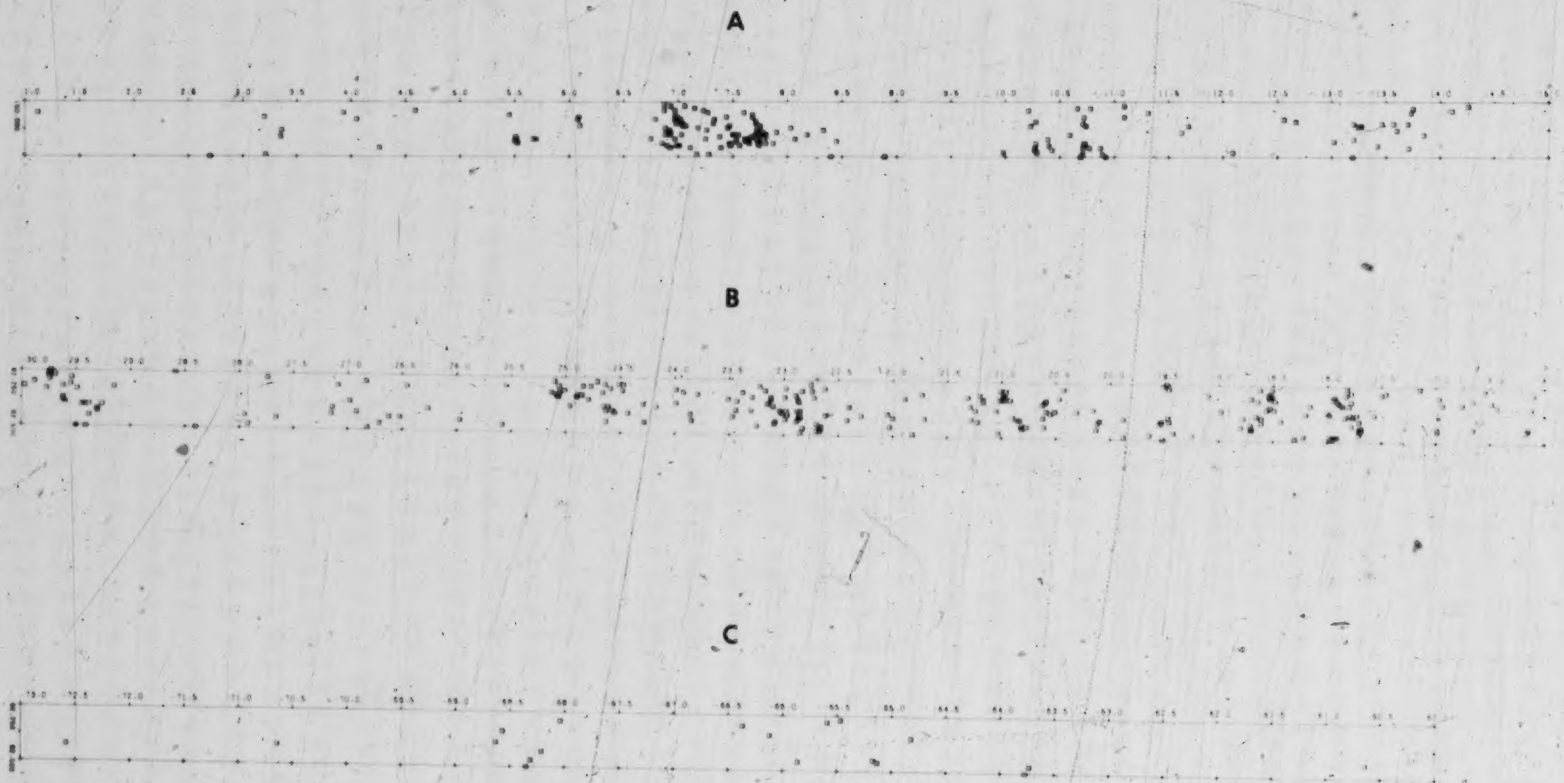


Figure 5. A) Moderate density segment of Transect I associated with Block B (running from 4.0 to 12.0 meters East). B) High density portion of Transect II running through Block C, which extended from -19.0 to -27.0 meters West. C) Low density segment of Transect II associated with Block D; that unit ran from -65.0 to -69.0 meters West. Half meter units appear above each segment. Vertical scale is exaggerated by a factor of two.

Transects I and II associated with Blocks B, C, and D.

Transects themselves are not well suited to the analysis of artifact association, a topic of obvious concern to the archaeologist. For this reason, larger block units were excavated (see Figure 3). Mean square block analysis, to be applied later, required that excavation blocks be either rectangular or square, with the length of a side being some power of two. Blocks A and D are 4 by 4 meters and Blocks B and C are 4 by 8 meters. Information from transects was used in making the placement of these units as representative as possible. On the basis of 1975 test data, Block A was located in an area of high density. 2609 artifacts were recovered, and of these, 82 were finished artifacts. Block B was located in an area of moderate density where 42 finished artifacts and a total of 756 artifacts of all types were recovered. Block C was placed in another high density area and yielded 2112 artifacts with 89 finished artifacts. Block D was situated in an area of low density, although there was one area of high concentration (345 artifacts in square 93). 89 finished artifacts and 535 artifacts altogether were recovered. Blocks A and B were at the southeast end of the site and Blocks C and D were at the northwest end of the site. Finally, Blocks A and D are located near water's edge, while Blocks B and C are farther back and at higher elevation.

Analysis reveals significant patterning within units of this size, but it should be pointed out that excavations of this size will only allow detection of spatial patterning at a comparatively small scale. Information on the spatial variability of artifact distributions over broader areas of the site could only be obtained with very large excavation units.

CHAPTER VI.

SPATIAL ANALYSIS

Distributions

In considering the dispersion of items in space (be they sessile organisms such as plants or inanimate objects such as artifacts or geographical locations), three kinds of distribution can arise (Kershaw 1973: 128). A random distribution refers to the situation in which the location of each item is independent of the location of other items. That is, the positioning of an item is not predictable. Distributions depart from randomness when:

1. Individual items tend to be clumped together.
2. Individual items tend to be regularly spaced.

In the first case, quadrat sampling is marked by both large numbers of empty quadrats and quadrats containing a large number of individuals. In the second case, quadrats all contain an intermediate number of individuals (*ibid.*). Maximum clumping occurs when all individuals occur at one locus. Maximum uniformity is attained when individuals are regularly spaced in a hexagonal pattern. These extremes in dispersion are best referred to as contagion or aggregation in the case of clumping, as opposed to regularity or uniformity in distributions (Greig-Smith 1964:60-61; Kershaw 1973:128).

Spatial analysis involves the use of statistical methods to assess the nature and significance of departures from randomness in distributions. The null hypothesis in such studies is that the population is randomly dispersed. If the density of the population is known, it is possible to derive an expected value for the sampling statistic under the hypothesis of randomness. This usually takes the form of an expected number of individuals per grid unit or an expected distance to a neighbouring item. When density is considerably less than the maximum possible density, frequently the case in plant ecology and invariably the case in archaeology, the significance of departures from randomness are best tested against the Poisson distribution, the distribution used to determine the probability of occurrences per unit area (cf. Greig-Smith 1964:57-58; Harnett 1975:146). It should be pointed out that although the pattern of distribution of a population is a real characteristic of that population, the demonstration of nonrandomness in a particular set of samples is not an absolute characteristic. Nonrandomness, like frequency of occurrence, depends upon the size and the shape of the sampling unit in use (Greig-Smith 1964:56).

If the distribution of items in a population is demonstrably nonrandom in the direction of aggregation, it is desirable to speak of the nature of the distribution. Several terms can be applied in this context (cf. Pielou 1969:118). The intensity of a spatial patterning means the extent to which density varies from place to place in the distribution. The grain or scale of a pattern remains independent of its intensity. In an aggregated distribution where the clumps or patches of higher density are large in area and widely spaced, the pattern is coarse-grained; a pattern is fine-grained when the total range of different densities occurs within a small area. Finally, a dichotomy between simple and complex patterning can be drawn. A simple pattern of contagion would involve aggregates of nonrandomly dispersed individuals. A complex pattern of distribution would involve patterning in the distribution of aggregates themselves (e.g., contagious or regular aggregates). Broadly, the latter situation is encompassed by the generalized and compound distributions which Pielou (1969:83-89) describes.

Archaeological Data

Pielou (1969:80) notes the existence of "wholly different setups" for the distribution of organisms in space. While plants allow much greater opportunity for spatial analysis than do motile organisms, several problems remain. Plant communities are large and complex enough that the recording of all locations of individuals is often not feasible. At the same time, not all species are typified by easily defined individuals. Aspen cloning is a case in point. Then too, the bulk of an individual plant can cause difficulty in assigning precise coordinates and in the choice of an appropriate random distribution model for testing. Use of the Poisson series requires that the density of items be well below maximum possible density (Greig-Smith 1964:57).

Archaeological data is better suited to spatial analysis. Artifacts are discrete entities which are easily recognized. There are few circumstances in which the representation of an artifact by a point in space is not perfectly adequate and concepts such as basal width or circumference to circumference (versus center to center) distance are not necessary to locate an artifact accurately. This is particularly true of the small lithic items making up the artifact record at HkPa 4. Larger cobbles and bones are rare or absent.

Methods

Mean Square Block Analysis

Two basic approaches can be adopted in the study of point patterns in space. On one hand, raw data takes the form of counts per grid unit, and on the other hand, we consider the distance from an individual or a point to its nearest neighbour or to its closest individual (Clark and

Evans 1954; Morisita 1954). Mean square block analysis, also referred to as the "dimensional analysis of variance" or the "analysis of a contiguous grid of quadrats and the detection of pattern", works on the basis of counts per grid unit (e.g., Thompson 1958).

Greig-Smith (1964:54-93) and Kershaw (1973:128-144) summarize the application of quadrat statistics. A mean number of individuals per grid unit is calculated from known density. Variance (from the mean) in quadrats is then calculated. Under the Poisson distribution, the variance equals the mean. In a random population, the variance/mean ratio is expected to equal unity. Significance of departure of the observed variance/mean ratio from the expected variance/mean ratio can be assessed by a t-test or by chi-square goodness of fit. It has been demonstrated, however, that both the size (Skellam 1952) and the shape (Clapham 1932) of the quadrat can influence density counts and hence, variance/mean ratios. It is necessary to make use of different quadrat sizes to accurately detect nonrandomness in a distribution, obviously a time consuming endeavour.

Mean square block analysis is a logical outgrowth of this problem of quadrat size (see Thompson 1958; Greig-Smith 1964:88-93; Kershaw 1973: 138-144; Whallon 1973b). In this case, a contiguous grid of T quadrats is laid out. Each side of this grid must be some power of 2 in length. The number of points in each quadrat (ultimate grid unit) is then counted. Analysis proceeds by the successive doubling of original quadrats into oblong followed by square blocks. (These "blocks" are not to be confused with whole excavation units such as "Block A". Excavation units will always appear in upper case.) Sums of squares for each block size of j quadrats are calculated according to the formula (Thompson 1958:326):

$$S_j = \frac{1}{j} \sum_{i=1}^{T/j} (B_{j(i)})^2$$

where $B_{j(i)}$ is the number of points in the ith block of j quadrats, and the values of B^2 are summed over all such blocks. T is the total number of quadrats in the grid. The "mean square between blocks" (M_j) can then be calculated:

$$M_j = \frac{(S_j - S_{2j})}{F_j}$$

where F_j is the degrees of freedom and is defined as

$$F_j = \frac{T}{2j}$$

A mean square/mean ratio is obtained by dividing the mean square by the mean number of items per block at that block size. Mean squares or mean square/mean ratios can be displayed graphically. As block size approaches the size of any actual concentrations, there is a greater tendency for concentrations to fall entirely within blocks, thus increasing the value of M_j. Therefore, graph peaks represent the block size at which spatial concentration occurs. It can be seen that this method allows a conceptualization of the scale or grain of a pattern.

Assessing the significance of peaks is difficult. Testing the significance of mean squares at larger block sizes against smaller block sizes (say, block size 1) by a variance ratio (F) test cannot be justified statistically. The F test requires the assumption that quadrat frequencies are normally and independently distributed, an assumption that is violated if items are aggregated in space (Thompson 1958:326). In plant ecology, Greig-Smith (1961:698) suggests relying upon consistency of peaks in a series of observations as evidence of ecological significance. At HkPa 4, only four sample units are involved. As an alternative, peaks can be assessed for statistical significance by plotting upper and lower significance bands for the mean square/mean ratio graph (Thompson 1958: 327; Greig-Smith 1961:698-699). High mean square/mean ratios peaking above the upper significance band indicate aggregation while low mean square/mean ratios falling below the lower significance band indicate uniformity.

Nearest Neighbour Analysis

Clark and Evans (1954) described a plotless method that requires coordinates for each individual. The basic data consists of distances from each item to the item nearest it, its "nearest neighbour". It is possible to compare observed nearest neighbour distances with expected nearest neighbour distances and test for statistically significant departures from expected values.

Density is given by

$$d = \frac{n}{a}$$

where n represents the number of items and a the area of the unit of analysis. The average observed distance from each item to its nearest neighbour is

$$\bar{r}_o = \frac{\sum_{i=1}^{n} r_i}{n}$$

where r_i is the nearest neighbour distance. Clark and Evans (*loc. cit.*) demonstrate that the expected average nearest neighbour distance in a random distribution is

$$\bar{r}_e = \frac{1}{2\sqrt{d}}$$

In an ideally random pattern, the ratio of the observed to the expected nearest neighbour distances (R),

$$R = \frac{\bar{r}_o}{\bar{r}_e}$$

is one. The value of R approaches zero as the limit for a perfectly aggregated distribution and equals 2.1491 in a uniform hexagonal pattern. Since R has an expected value with an upper and lower limit, it is possible to assess the statistical significance of departures from unity. Clark and Evans (ibid.) accomplished this by using the standard normal variate:

$$C = \frac{\bar{r}_o - \bar{r}_e}{\sigma_{r_e}}$$

where σ_{r_e} is the standard error of the mean for the distances to nearest neighbours in a population of randomly distributed items of the same density as the observed population. This application requires the assumption that the distribution of nearest neighbour distances is normal and would be valid only with large samples. In practice, the C statistic appears highly susceptible to a few extreme distances. To avoid these difficulties, nearest neighbour statistics are usually tested against the chi-square distribution (cf. Thompson 1956:393-394; Pielou 1959:608-609; Whallon 1974:19-21).

These statistics are based on the Poisson distribution. Poisson probabilities are determined by the mean number of items per unit area. Normally square units of area are converted into circles so that the statistics derived are related to distances radiating from an item. Conversion is made with the factor

$$\lambda = \pi d$$

Chi-square is then defined as

$$\chi^2 = 2\lambda \sum_{i=1}^{n} r_i^2$$

where r_i^2 is the nearest neighbour distance squared. Here, chi-square is distributed with 2n degrees of freedom. When n is a moderate value (greater than 30, say) it is impractical to read values from a table. Chi-square is easily converted to a standard normal deviate:

$$S = \sqrt{2\chi^2} - \sqrt{2F - 1}$$

where F is the degrees of freedom. The standard normal deviate can be evaluated with normal curve tables. Usually, however, it is the chi square normal approximation, given below, for which confidence intervals are calculated:

$$x_j = \frac{\chi^2}{n}$$

These are defined as

$$CI = \frac{(\sqrt{2F - 1} \pm t)^2}{2n}$$

The Wilson-Hilferty approximation provides for slightly more accuracy (cf. Dacey 1963:508).

$$CI = \frac{F}{N}\left[1 - \frac{2}{9F} \pm t\sqrt{\frac{2}{9F}}\right]^3$$

In summary, R values that are less than one indicate a departure from randomness in the direction of aggregation--nearest neighbour distances are smaller than expected under the null hypothesis of randomness. R values greater than one, that is, where observed distances are greater than expected under the hypothesis of randomness, depart from randomness in the direction of uniformity. The R index measures only intensity, not scale: denser clumps have shorter neighbour distances. Consequently, they have smaller R values (Pielou 1969:119).

Order Neighbour Statistics

Clark and Evans (1954) indicated that the extension of nearest neighbour analysis to 2nd, 3rd, 4th,...nth nearest neighbour would involve substantially more complex formulae. This notion appears to have become embedded in the literature (cf. Greig-Smith 1964:74) and the method has not been widely used. In archaeology, Whallon (1974) has already suggested that order neighbour statistics will be of little use. Thompson (1956), however, soon derived the necessary formulae, and they are not particularly complex. Order neighbour statistics are clearly well suited to providing a more detailed look at aggregation. As Thompson (1956:393) expresses this, we intuitively expect to find departures from randomness in the first few neighbour distances and an approach to randomness thereafter. Each R value provides a measure of pattern intensity at an order neighbour, while variation in a sequence of R values is related to pattern grain.

Formulae already presented need only to be generalized for dimension and order. Order distances belong to the gamma distribution. (See Dacey (1963) and Thompson (1956) for derivations.) F, degrees of freedom, is calculated as follows:

$$F = mnj$$

where n is the number of items in the sample, m is dimension in hyperspace (fixed at 2 here), and j is the order neighbour. Expected mean distance to the jth nearest neighbour is given by

$$E(\overline{r}_j) = \frac{1}{\sqrt{d}} \, \frac{(2j)!(j)}{((2^j)j!)^2}$$

In practice, we use the same λ factor to define the mean number of individuals in a circle of unit radius. All neighbour distances at a given order are found and the chi-square normal approximation is calculated by the following:

$$\overline{X}_j = \frac{2}{n} \lambda \sum_{i=1}^{n} (r_j)^2$$

With the appropriate value of F, confidence intervals, as defined previously, can be calculated.

Density Contouring

Mean square block analysis involves fairly simple statistics and is not difficult to apply to large populations. It will be used in a consideration of patterning for all artifacts recovered. Distance measures require a somewhat greater computation load, and become impractical in instances where density for all artifacts is high (e.g., the 2609 artifacts in Block A). Further insight into patterning in the total artifact distribution can be gained by plotting density isonomes. Block units are gridded off and the number of items in each grid unit counted. Frequencies for each grid unit become density values. Density values are represented as points in the center of each grid square, and it is these points which are contoured. Half meter by half meter grid units were applied. Greatest contouring accuracy is achieved by offsetting grid squares one half unit, thereby allowing triangulation in contouring.

CHAPTER VII.

RESULTS AND DISCUSSION

Artifact distributions are presented in Appendix A. Figures 6-9 are finished artifacts for excavation Blocks A, B, C, and D, respectively, while figures 10-13 are the total artifact distributions for these units. Finished artifact symbols are accompanied by two and three character labels. The alphabetic portions of the labels, listed in Table 2, represent artifact class. Numeric labels indicate material of manufacture.

Mean Square Block Analysis of Finished Artifacts

It had been hoped to achieve some understanding of the variable scale of clustering that might occur in these distributions by utilizing the mean square block analysis technique. However, there are a number of practical and theoretical drawbacks in its application.

Practical problems can be controlled for in research design. Mean square block analysis requires a square or rectangular sampling grid with sides some power of 2. If it is known in advance that mean square block analysis will be applied, samples can be taken with this factor in mind. Another problem with the technique is that it can only detect patterning at or above the smallest block size (Hodder and Orton 1976: 38). Distance measures were to be applied to the data under consideration, and coordinates are known. When this is the case, original block size can be adjusted downward. It should be noted that analysis still proceeds by doubling of block size; reducing the original block size does not provide finer detail at larger block sizes. A peak for a block size equal to 16 units means only that mean patch area lies between block sizes for 8 and 32 units (Pielou 1969:105).

TABLE 2

LABELS FOR PLOTTING HkPa 4 ARTIFACTS*

E - used flake
F - retouched flake
G - split pebble/ bipolar split pebble
H - core
I - small biface
J - endscraper
K - large uniface
L - large biface
M - spall tool
N - cobble tool
O - bone tool
P - hammerstone
Q - wedge
U - sidescraper

1 - quartzite
2 - Beaver Creek Quarry quartzite
3 - black chert
4 - argillite
5 - other chert
6 - quartz
7 - salt and pepper quartzite
8 - heat treated quartzite
9 - heat treated salt and pepper quartzite
10 - sandstone
11 - low grade quartzite
12 - bone

*Composite labels indicating artifact class and material (e.g., E1, I5, J8) appear in Figures 6-9, Appendix A.

Theoretical problems are of much deeper significance (Pielou 1969: 105). First, mean square vs. block size graphs can only be judged subjectively. Mean squares for different block sizes cannot, in fact, be regarded as statistically independent because they are calculated from counts obtained by successively combining the same blocks rather than from independent samplings of the distribution with different sized quadrats. Second, graphs sometimes assume a saw-toothed shape because oblong blocks give mean squares consistently less than those of square blocks on either side of them in the sequence of block sizes. Third, Pielou (ibid.) shows that a clumped pattern and its reverse (where clumps become lacunae and empty areas are filled with randomly dispersed points) give highly similar patterns. Finally, and this is the most debilitating flaw of the technique as applied to the data I have, variance/mean ratio tests apparently behave erratically when the mean is very small (i.e., in low density situations) (Greig-Smith 1964:70).* The combination of practical and theoretical problems warrant caution in the application and interpretation of this test. As Hodder and Orton (1976:38) suggest, more sensitive tests based on distance measures appear more appropriate for low density archaeological data.

Block D has served as a test case for all of the techniques described here. Three distinct and separate clusters are present. Mean square block analysis reveals significant patterning for Block D only. This probably results from the intensity of patterning in this unit, despite overall low density. Results are presented in Table 3 and Figure 14, Appendix B. Application of significance bands to the mean square/mean ratio vs. block size graph indicates:

1. The distribution is nonrandom in the direction of aggregation.

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*One other difficulty arises. The program used for mean square block analysis actually began with the complete excavation block (the last block size) and worked downward ("divisive rather than agglomerative"). Output is actually the reverse of the computational procedure. This feature made it easy to transpose the actual division of the block, thus orienting oblong blocks in both possible directions. Thompson (1958:325) states that either direction is satisfactory, if there is no trending, as long as orientation is consistent. Trending is not manifest in this data, but results, particularly for all artifacts (high density), sometimes include significant differences when axes are transposed at the same original block size. If one cannot visually discern trending prior to testing, it is difficult to know which results to accept. When axes are transposed for rectangular blocks, the divisive process results in all block sizes being rectangular (e.g., 0.125 by 0.50, followed by 0.25 by 1.0, followed by 0.50 by 2.0, etc.). This is a partial solution to Pielou's second complaint (above).

TABLE 3

MEAN SQUARE BLOCK ANALYSIS
FINISHED ARTIFACTS, BLOCK D, HkPa 4

NUMBER OF ARTIFACTS 89
LENGTH OF THE X-AXIS 4 METERS
LENGTH OF THE Y-AXIS 4 METERS
BEGINNING BLOCK SIZE 0.25 BY 0.25 METERS
MEAN DENSITY AT BLOCK SIZE 1 0.3477

BLOCK SIZE	SUMS OF SQUARES	MEAN SQUARES	MEAN SQUARE/ MEAN RATIO	DF
1	1087.0000	0.8398	2.4157	256
2	979.5000	3.0508	4.3876	128
4	784.2500	10.9492	7.8736	64
8	433.8750	11.6680	4.1952	32
16	247.1875	14.6914	2.6412	16
32	129.6563	10.6289	0.9554	8
64	87.1406	18.2539	0.8204	4
128	50.6328	19.6914	0.4425	2
256	30.9414			1

AXES ARE TRANSPOSED

2. A single scale of patterning is present at block size 4, or 0.5 by 0.5 meters, a reasonable approximation for the three clusters.

Other excavation blocks (A,C, and D) show no significant results when tested. However, patterning is not as intense and density is low. In Block B, where a tendency toward clustering seems evident to the eye, low mean square/mean ratios are reported (Table 4). Forty-two artifacts are present; if the original block size is reduced to 0.25 by 0.25 meters, we have a density of 42 items over 512 quadrats, considerably less than one item per unit. Because of this density problem, I have not applied indices such as David and Moore's Index of Aggregation or Lloyd's Indices of Mean Crowding and Patchiness (cf. Pielou 1969:91-98).

Order Neighbour Statistics

Because simple nearest neighbour statistics restrict enquiry to the most detailed scale and the nearest neighbour is the first order neighbour, we will move directly to a consideration of order neighbour statistics.

TABLE 4

MEAN SQUARE BLOCK ANALYSIS
FINISHED ARTIFACTS, BLOCK B, HkPa 4

NUMBER OF ARTIFACTS 42
LENGTH OF THE X-AXIS 8 METERS
LENGTH OF THE Y-AXIS 4 METERS
BEGINNING BLOCK SIZE 0.25 BY 0.25 METERS
MEAN DENSITY AT BLOCK SIZE 1 0.0820

BLOCK SIZE	SUMS OF SQUARES	MEAN SQUARES	MEAN SQUARE/ MEAN RATIO	DF
1	56.0000	0.0742	0.9048	512
2	37.0000	0.1250	0.7619	256
4	21.0000	0.1289	0.3929	128
8	12.7500	0.1289	0.1964	64
16	8.6250	0.1445	0.1101	32
32	6.3125	0.0820	0.0313	16
64	5.6563	0.5195	0.0990	8
128	3.5781	0.0508	0.0048	4
256	3.4766	0.0313	0.0015	2
512	3.4453			1

AXES ARE TRANSPOSED

As with mean square block analysis, there are procedural difficulties. These stem from a "border effect". To analyze the problems created by this effect archaeological data has been supplemented by distributions from the Schultz Population Sampler, Department of Botany, University of Alberta. The artificial population sampler consists of two 1 meter square plexiglass surfaces. On one surface, coloured disks are randomly dispersed. Random, regular, and aggregated distributions appear on the second board. The distribution of white disks from the random board of the Schultz Population Sampler appears in Figure 19.

In the original exposition of the nearest neighbour method, Clark and Evans (1954:450) pointed out that theoretical spatial analyses assume an infinite area for the sampling universe. Practically, distance measures are applied to finite populations, and,

> The presence of a boundary beyond which measurements cannot be

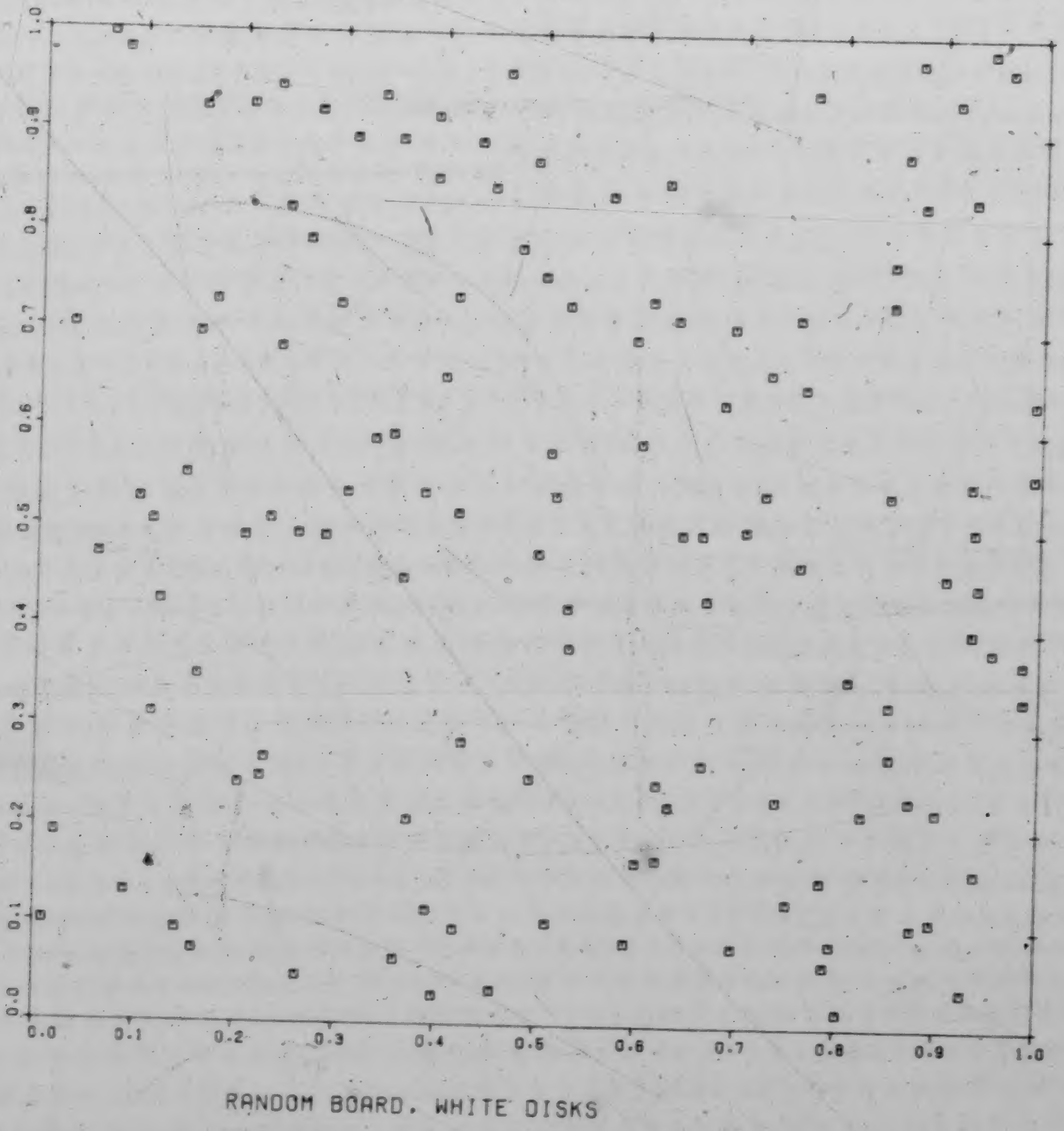

Figure 19. The distribution of white disks on the random board of the Shultz artificial population sampler.* This random distribution served as a test case for the point rejection method of handling border effect in nearest neighbour analysis.

> made will tend to make the value of r_A [sum of all the nearest neighbour measurements] greater than would be obtained if an infinite area were involved (loc. cit.).

They suggest that, whenever possible, it will be desirable to select an area for investigation that lies well within the total area covered by the entire population. Dacey (1963:505) agreed that the boundary of the region containing the pattern is a potential source of bias, and concluded that for most applications, measurements from a point i (in the context of locational analysis in geography) should only be recorded for those j neighbours which are closer to i than i is to the boundary. In an archaeological instance, where item to item distances were used, Whallon (1974) rejected any point which was closer to a boundary than to its nearest neighbour.

Of the two corrections for border effect, the point rejection method is the more dangerous. Clark and Evans' "centralized unit" copes with greater neighbour distances by eliminating the original border. As Diggle (1976) warns, point rejection favors selective bias towards smaller neighbour distances. Yet, we must be especially skeptical about systematically rejecting data in a way that could favor the rejection of the null hypothesis (randomness) when it is actually true. Technically, this is termed Alpha or Type I error and is to be contrasted with the problem point rejection is trying to solve, Beta or Type II error, which is failure to reject the null hypothesis when it is actually false (Blalock 1972:113-116). Could point rejection in effect "overcompensate" for the retention of some larger neighbour distances through border effect?

Before answering this question, rejection criteria must be set. It is felt that centrally located, but isolated items should be retained. Since surrounding areas have been excavated, we know an artifact is genuinely isolated. Rejecting any point closer to the border than it is to its nearest neighbour, the solution offered in the literature, would lead to the rejection of such items. A more conservative approach is adopted here. A "critical boundary" is created within the original excavation unit. If the critical boundary area is 20 centimeters from each wall, only points falling within 20 centimeters of each wall will be tested to see if they are closer to the border than to their nearest neighbour. Thus, isolated points in the center of the block (not in the critical boundary) are never tested and are retained. These criteria are laid out in Figure 20.

REJECTION CRITERIA IN NEAREST NEIGHBOUR ANALYSIS

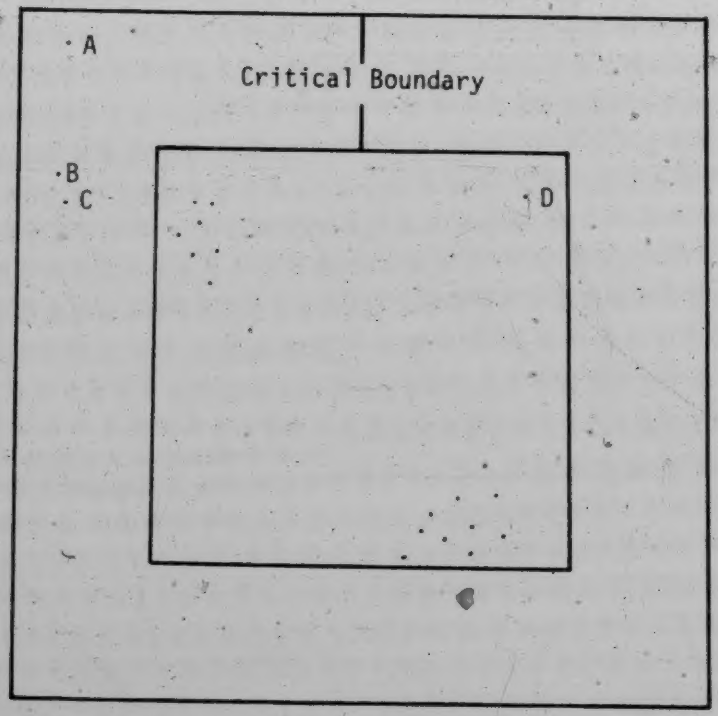

FIGURE 20. Point A is rejected while points B and C are tested and retained. An isolated point such as D does not fall within the critical boundary area and is not tested.

Results of testing with point rejection are presented in Table 5.* A critical boundary of 0.0 meters means that no rejection took place. The critical boundary is incremented by 10 centimeters up to 40 centimeters. For excavation units (Blocks A-D), in every case, significance in the direction of aggregation increases with an increasing critical boundary (i.e., more points are being rejected). With no point rejection, Block A tests as completely random over 10 order neighbours. Increase the critical boundary to 20 centimeters and the distribution tests as significantly aggregated over 10 order neighbours. Table 6 demonstrates the problem even more clearly. The white disks on the Schultz Population Sampler random board were intentionally generated as a random distribution. When that distribution is tested, it is random for first and second nearest neighbours, and then tests as significant in the direction of uniformity (first line of Table 6). A centrally located unit of 0.75 by 0.75 meters is drawn and tested without point rejection. Test results are the same (second line of Table 6). If we create a critical boundary of 10 centimeters within the centralized unit and reject points within it, the distribution tests as significantly aggregated at all 10 order neighbours.

Something is seriously wrong, and it is my contention that point rejection causes systematic selection for smaller nearest neighbour distances, thereby creating Alpha error. I cannot overemphasize that these results are obtained by using an even more conservative rejection method than that suggested in the literature. Without question, point rejection is not a viable method for dealing with border effect.

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*Distributions in the East and West halves of Block C appeared different. Test results are consistently different and the former unit tests as random. The East half of Block C was not submitted to the final stage of analysis, cluster analysis.

TABLE 5

NEAREST NEIGHBOUR ANALYSIS OF EXCAVATION UNITS, HkPa 4, POINT REJECTION

Sampling Unit	Critical Boundary (meters)	Order Neighbour									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
BLOCK A	0.0	R*	R	R	R	R	R	R	R	R	R
	0.1	R	R	SA	R	SA	SA	SA	SA	SA	SA
	0.2	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
	0.3	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
	0.4	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
BLOCK B	0.0	SA	R	R	SA	R	R	SU	SU	SU	SU
	0.1	SA	R	SA	SA	SA	R	R	SU	SU	SU
	0.2	SA	SA	SA	SA	SA	SA	R	SU	SU	SU
	0.3	SA	SA	SA	SA	SA	SA	SA	R	SU	SU
	0.4	SA	SA	SA	SA	SA	SA	SA	R	SU	SU
BLOCK C, EAST HALF	0.0	R	R	R	SU	SU	SU	SU	SU	SU	SU
	0.1	R	R	R	SU	SU	SU	SU	SU	SU	SU
	0.2	R	R	R	R	R	SU	SU	SU	SU	SU
	0.3	R	R	R	R	R	R	R	R	R	SU
	0.4	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
BLOCK C, WEST HALF	0.0	R	SA	R	R	R	SU	SU	SU	SU	SU
	0.1	SA	SA	R	R	R	R	R	R	R	SU
	0.2	SA	SA	SA	R	SA	SA	R	R	R	R
	0.3	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
	0.4	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
BLOCK D	0.0	SA	SA	SA	SA	SA	SA	SA	SA	SU	R
	0.1	SA	SA	SA	SA	SA	SA	SA	SA	SU	R
	0.2	SA	SA	SA	SA	SA	SA	SA	SA	R	SA
	0.3	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
	0.4	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

* R - No significance of pattern found; distribution shows no significant departure from randomness.

SA - Significance found in the direction of aggregation.

SU - Significance found in the direction of uniformity.

We are left with the option suggested by Clark and Evans (op. cit.). It does not impose a selective bias and for this reason is a much better solution to the border effect. Here, a centralized unit smaller than the

TABLE 6

POINT REJECTION TEST, WHITE DISKS, RANDOM BOARD

		Order Neighbour									
Sample	Critical Boundary (meters)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
All white disks, no rejection	0.00	R	R	SU	SU	SU	SU	SU	SU	SU	SU
0.75 by 0.75 meter centered unit, no points rejected	0.00	R	R	SU	SU	SU	SU	SU	SU	SU	SU
0.75 by 0.75 meter centered unit, points rejected from 0.10 meter critical boundary	0.10	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

original sample unit is created and tested.* Nearest neighbours can be found outside of the centralized unit, but only distances for items within the centralized unit are used in calculation. Results for artifact distributions and disks from the Schultz random board are presented in Table 7.

There are differences from the results obtained for the whole board (presented again in Table 8). Significance in the direction of uniformity disappears and is replaced by randomness in nearly all instances. This is difficult to explain, although it obviously is not as serious an error as that induced by point rejection (from uniformity to aggregation). The tendency for uniformity to appear in supposedly random distributions on the Schultz Population Sampler is curious (unaltered sample). Note

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*The program in use can be easily modified from the point rejection format by changing an "if" statement to exclude everything in the critical boundary area. All the points read in are available for neighbours to an item, but only items in the central unit figure in the statistics which are calculated. An example of output is presented in Appendix C.

TABLE 7

CLARK AND EVAN'S METHOD: CENTRALIZED UNIT

		Order Neighbour									
Sample	Distance Inset (meters)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
BLOCK A	0.5	R	R	R	R	R	SA	R	R	R	R
BLOCK B	0.5	SA	R	R	R	R	R	R	SU	SU	SU
BLOCK C, WEST HALF	0.5	R	R	R	R	R	SA	R	R	R	R
BLOCK C, EAST HALF	0.5	R	R	R	R	R	R	R	R	R	R
BLOCK D	0.5	SA	SA	SA	SA	SA	SA	SA	SA	R	SA
RANDOM BOARD											
RED DISKS	0.2	R	R	R	R	R	R	R	R	R	R
GREEN DISKS	0.3	R	R	R	R	R	R	R	R	R	R
WHITE DISKS	0.125	R	R	R	R	R	R	R	R	R	R

TABLE 8

NEAREST NEIGHBOUR ANALYSIS OF UNMODIFIED SAMPLING UNITS*

	Order Neighbour									
Sampling Unit	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
BLOCK A	R	R	R	R	R	R	R	R	R	R
BLOCK B	SA	R	R	SA	R	R	SU	SU	SU	SU
BLOCK C, WEST HALF	R	SA	R	R	R	SU	SU	SU	SU	SU
BLOCK C, EAST HALF	R	R	R	SU	SU	SU	SU	SU	SU	SU
BLOCK D	SA	SA	SA	SA	SA	SA	SA	SA	SU	R
RANDOM BOARD										
RED DISKS	R	SU	SU	SU	SU	SU	SU	SU	SU	SU
GREEN DISKS	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU
WHITE DISKS	R	R	SU	SU	SU	SU	SU	SU	SU	SU

*Results for testing with no correction for border effect.

-9

that the green disks depart from randomness in the direction of uniformity at all order neighbours. I encountered the same difficulty in attempting to generate a random distribution for purposes described below. It seems possible that since nearest neighbour statistics are theoretically derived for an infinite population distributed over an infinite space, any attempt to generate a random distribution within a small enclosed unit may result in a tendency toward uniformity. Hodder and Orton (1976:41-42) report a similar result. Alternatively, it is possible that significance in the direction of uniformity in these units results from the chance production of nonrandom distributions, although encountering this difficulty in three separate instances seems more than coincidental.

For archaeological data, there remains an even more serious problem. The Clark and Evans method is extremely wasteful of data, and archaeological data is often a scarce resource to begin with. Consider Block B. The centralized unit was located one half meter from each border. This removed or truncated two of the denser clusters in a low density distribution. A solution to this dilemma comes in the form of _adding_ a border to the original observation unit. Hodder and Orton (1976:42) report success with this method, although further research is necessary. They suggest that

> If the sampling area is rectangular in shape and contains a fairly large number of points, and if one can assume that a similar picture would hold for sampling fields, one can repeat the same set of points top and bottom and at the sides (_ibid_.).

The surrounding band consists of randomly placed points (with coordinates derived from random number tables) having the same density as the interior study area.* The sampling strategy used at HkPa 4 precludes making assumptions of this nature about the total distribution. Of course, two blocks are not rectangular. For these reasons, rectangular border areas (for Block B, two 10 by 1 meter and two 4 by 1 meter strips) were created and filled with points whose coordinates were chosen from a random numbers table. Density equalled that of the original unit. Each of the four border strips for a unit were filled separately. The 1 meter random border attached to Block B appears in Figure 21.

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*Although Hodder and Orton's use of the term "same set" leaves uncertainty about randomness and equal density.

An alternative to a random border would be to surround a block with its own distribution on all sides. A border area could be selected from this surrounding area. Again, this method requires assumptions about the total distribution at HkPa 4 that cannot be made without further sampling. While the archaeologist may be searching for regularities in distributions, it should be recalled that occupation floors or distributions at sites like HkPa 4 may have distinctly unique characteristics. Perhaps the best test involving an added border would utilize computer methods to generate a large random distribution from which a central area the size of the study block could be removed.

Results for block units with an added random border are presented in Table 9. Block D was not tested because the small, high density clump in the northwest corner of that unit consistently leads to significant aggregation at all order neighbours regardless of the type of test employed. The West half of Block C is not as strongly clumped. The real East border for the West half of Block C is known and was used. Artifacts do tend to be distributed in small groups of two and three (nonrandomness in first and second neighbours), although larger groupings appear to occur. Block B is more strongly contagious, as might be suspected from visual inspection. Clusters of two to nine items do occur; significance in the direc-

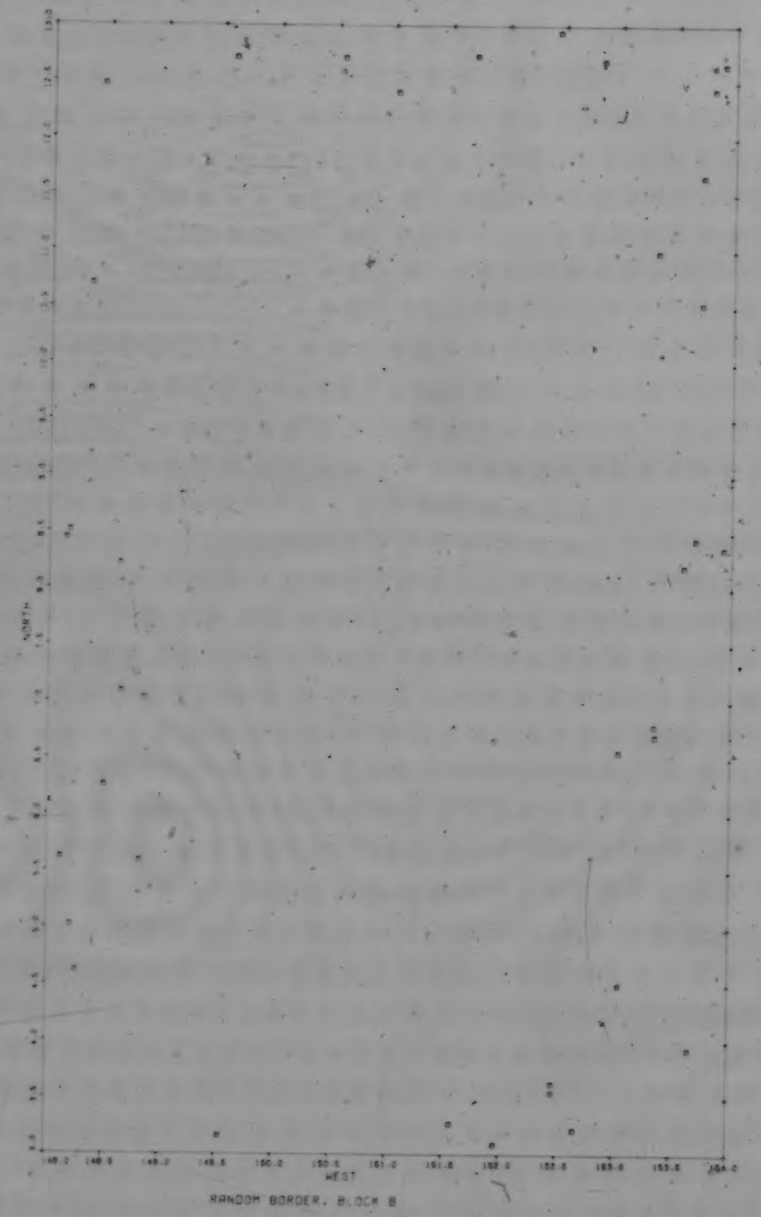

Figure 21. The one meter border area attached to Block B for use in the random border method of handling border effect. The border has the same density of items as Block B, which fits within the blank area. Coordinates in the border area were chosen from a random numbers table.

TABLE 9.

RANDOM BORDER METHOD APPLIED TO EXCAVATION UNITS AT HkPa 4

Sampling Unit	Width of Border Added (meters)	Order Neighbour									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
BLOCK A	1.0	R	R	R	R	SA	SA	SA	SA	SA	SA
VALUE OF R		0.8799	0.9129	0.9014	0.0165	0.8984	0.8819	0.8842	0.8868	0.9109	0.9084
BLOCK B	1.0	SA	SA	SA	SA	SA	SA	SA	SA	R	R
VALUE OF R		0.6690	0.7564	0.8130	0.8062	0.8327	0.8571	0.8745	0.9045	0.9727	0.9647
BLOCK C WEST HALF	1.0	SA	SA	R	R	R	R	R	R	R	R
VALUE OF R		0.8373	0.8252	0.9397	0.9498	0.9357	0.9388	0.9787	0.9897	0.9846	0.9818

tion of uniformity occurs for the eighth, ninth, and tenth nearest neighbours if this unit is tested unaltered or by the Clark and Evans method. This could (given the constraints upon testing in this way) mean that aggregates tend to occur farther apart than expected. Block A provides unusual results. The distribution is significantly aggregated only at higher order neighbours. R values do not indicate intense patterning. Two factors may explain this. First, it is a 4 by 4 meter unit. This is rather small when we recall that the other 4 by 4 meter unit, Block D, is marked by particularly intense patterning. Second, extremely high total artifact density (not just finished artifacts) suggests heavy usage and a high probability of cluster overlap. We may be looking at a unit close to the size of a large nonrandom aggregate. The distribution within that aggregate may approach randomness, while higher order neighbours remain closer than expected under the null hypothesis.

Analysis of Complete Artifact Distributions

As mentioned previously, complete artifact distributions were analyzed by means of mean square block analysis and contouring only. Results of mean square block analysis are presented in Tables 10-13 and Figures 15-18, Appendix B. In each case, peaking occurs well above significance bands, and it is suggested that the distributions are definitely nonrandom. By and large, patterning is not detected at multiple scales. Throughout the four excavation blocks, the strongest peaking consistently occurs at the 0.50 by 0.50 meter quadrat size. This is a fair representation of actual concentrations observed visually. Failure to detect patterning at larger scales favors the conclusion that at least 4 by 4 meter excavation units are somewhat small, and capable of detecting only finer grained patterning. Generally, results presented are confirmed by varying

TABLE 10

```
MEAN SQUARE BLOCK ANALYSIS
ALL ARTIFACTS, BLOCK A, HkPa 4

NUMBER OF ARTIFACTS   2609
LENGTH OF THE X-AXIS  4 METERS
LENGTH OF THE Y-AXIS  4 METERS
BEGINNING BLOCK SIZE 0.50 BY 0.50 METERS
MEAN DENSITY AT BLOCK SIZE 1  40.7656
                                             MEAN SQUARE/
BLOCK SIZE   SUMS OF SQUARES  MEAN SQUARES   MEAN RATIO      DF
         1    170214.0000       517.4375     12.6930         64
         2    153656.0000       642.3438      7.8785         32
         4    143378.5000      1720.3750     10.5504         16
         8    129615.5000      1082.6563      3.3198          8
        16    125284.8750      6039.1875      9.2590          4
        32    113206.5000      6930.5000      5.3128          2
        64    106276.0000                                     1

AXES ARE TRANPOSED
```

TABLE 11

```
MEAN SQUARE BLOCK ANALYSIS
ALL ARTIFACTS, BLOCK B, HkPa 4

NUMBER OF ARTIFACTS   756
LENGTH OF THE X-AXIS  8 METERS
LENGTH OF THE Y-AXIS  4 METERS
BEGINNING BLOCK SIZE 0.50 BY 0.50 METERS
MEAN DENSITY AT BLOCK SIZE 1  5.9063
                                             MEAN SQUARE/
BLOCK SIZE   SUMS OF SQUARES  MEAN SQUARES   MEAN RATIO      DF
         1     14812.0000        64.6250     10.9418        128
         2     10676.0000        92.6563      7.8439         64
         4      7711.0000        59.0000      2.4974         32
         8      6767.0000       101.9063      2.1567         16
        16      5951.7500       201.0938      2.1280          8
        32      5147.3750       305.1250      1.6144          4
        64      4537.1250        72.0000      0.1905          2
       128      4465.1250                                     1

AXES ARE TRANSPOSED
```

TABLE 12

MEAN SQUARE BLOCK ANALYSIS
ALL ARTIFACTS, BLOCK C, HkPa 4

NUMBER OF ARTIFACTS 2112
LENGTH OF THE X-AXIS 8 METERS
LENGTH OF THE Y-AXIS 4 METERS
BEGINNING BLOCK SIZE 0.50 BY 0.50 METERS
MEAN DENSITY AT BLOCK SIZE 1 16.5000

BLOCK SIZE	SUMS OF SQUARES	MEAN SQUARES	MEAN SQUARE/ MEAN RATIO	DF
1	102588.0000	393.1094	23.8248	128
2	77429.0000	606.4219	18.3764	64
4	58023.5000	483.5313	7.3262	32
8	50287.0000	513.9375	3.8935	16
16	46175.5000	1800.1875	6.8189	8
32	38974.7500	1958.3125	3.7089	4
64	35058.1250	210.1250	0.1990	2
128	34848.0000			1

AXES ARE TRANSPOSED

TABLE 13

MEAN SQUARE BLOCK ANALYSIS
ALL ARTIFACTS, BLOCK D, HkPa 4

NUMBER OF ARTIFACTS 535
LENGTH OF THE X-AXIS 4 METERS
LENGTH OF THE Y-AXIS 4 METERS
BEGINNING BLOCK SIZE 0.25 BY 0.25 METERS
MEAN DENSITY AT BLOCK SIZE 1 2.0898

BLOCK SIZE	SUMS OF SQUARES	MEAN SQUARES	MEAN SQUARE/ MEAN RATIO	DF
1	29451.0000	12.9805	6.2112	256
2	27789.5000	43.6601	10.4458	128
4	24995.2500	357.1602	42.7257	64
8	13566.1250	354.7070	21.2161	32
16	7890.8125	422.2070	12.6268	16
32	4513.1563	422.6367	6.3198	8
64	2822.6094	472.4258	3.5322	4
128	1877.7578	759.6914	2.8400	2
256	1118.0664			1

AXES ARE TRANSPOSED

the initial quadrat size and by transposing the axes.

Multiple scaling does occur in Block A. Note, however, that peaks in the mean square/mean ratio correspond to square quadrat sizes. Patterning of this type is probably spurious in that it is likely related to the efficiency of sample unit shape. Oblong blocks tend to reduce between quadrat variances.

Contouring with density isonomes visually confirms this tendency toward spatial concentration. Density isonomes are presented as overlays associated with Figures 6-9, Appendix A. This format allows a comparison of finished artifact and total artifact distributions. It is clear that high density debitage areas coincide nicely with clusters of finished artifacts. In fact, of the 18 clusters defined by the next stage of analysis, 16 are strongly associated with "topographic highs" on the contour maps. However, several high density areas of debitage are not associated with any concentration of finished artifacts.

CHAPTER VIII.

DEFINITION OF SPATIAL CLUSTERS

Rationale

To this point, I have successfully demonstrated that artifact distributions in the block units are both nonrandom and aggregated. Apart from the more general reasons cited previously, the demonstration of nonrandomness is also essential for methodological reasons. If the investigator wishes to proceed directly to the analysis of spatial association, a prior demonstration of nonrandomness is desirable because spatial association in a random distribution of artifacts is probably unlikely (although it is not impossible, as Dacey (1973:32) implies). More importantly, the techniques for identifying spatially discrete artifact clusters applied below would form clusters within a random distribution--obviously allowing spurious conclusions.

Analysis can now proceed in a number of different directions. Grid methods (e.g., Dacey 1973) of assessing spatial association are not applied here primarily because low density remains a problem that could influence results. In addition, such methods would permit no clear control over temporal variability. Whallon (1974:23) has suggested another procedure in which a "cut-off" distance is determined:

> The standard deviation of the nearest neighbour distances is calculated, and a point 1.65 standard deviations above the mean nearest neighbour distance establishes the "cut-off" distance. This encompasses 95% of the potentially significant distances between items in the spatial distribution. A one-tailed criterion is used, since only distances greater than the mean can be considered significantly beyond the range of distances among items within a cluster (Whallon 1974:23).

The cut-off distance becomes the radius of a circle drawn about each item within a class of artifacts. Overlays of different artifact classes are made, and the amount of distributional overlap between classes is measured. Jaccard's index of similarity is then used to assess the degree of overlap between classes.

Here, a somewhat different approach is used. Finished artifact density is low. Artifact distributions are nonrandom and they are nonrandom in the direction of aggregation. Furthermore, the behavioral processes generating the distributions are suspected to lead to artifact clustering at loci for various activities. Therefore, it is reasonable to attempt to define spatial clusters of artifacts. The artifact cluster then becomes the unit in which spatial association occurs. Using this strategy, there is no need to worry about the effect differing grid sizes can have upon association. Some means of identifying clusters is required.

Methods

A Nearest Neighbour Derived Method

One way of defining spatial clusters involves a slight modification of the procedure Whallon adopted. All artifacts falling with the cut-off distance of each other are joined. A circle with a radius of the mean observed nearest neighbour distance can then be drawn around each artifact (or for simplicity, each outlying artifact). This makes it possible to discern visually discrete spatial aggregates of artifacts. Figure 22 shows the application of this approach to Block B. The limitation of this technique is not unlike the limitation of simple nearest neighbour analysis. The latter measures only pattern intensity. The "cut-off" method just outlined focuses on the smallest, most detailed scale of nonrandomness present. There is no way of assessing pattern scale or grain.

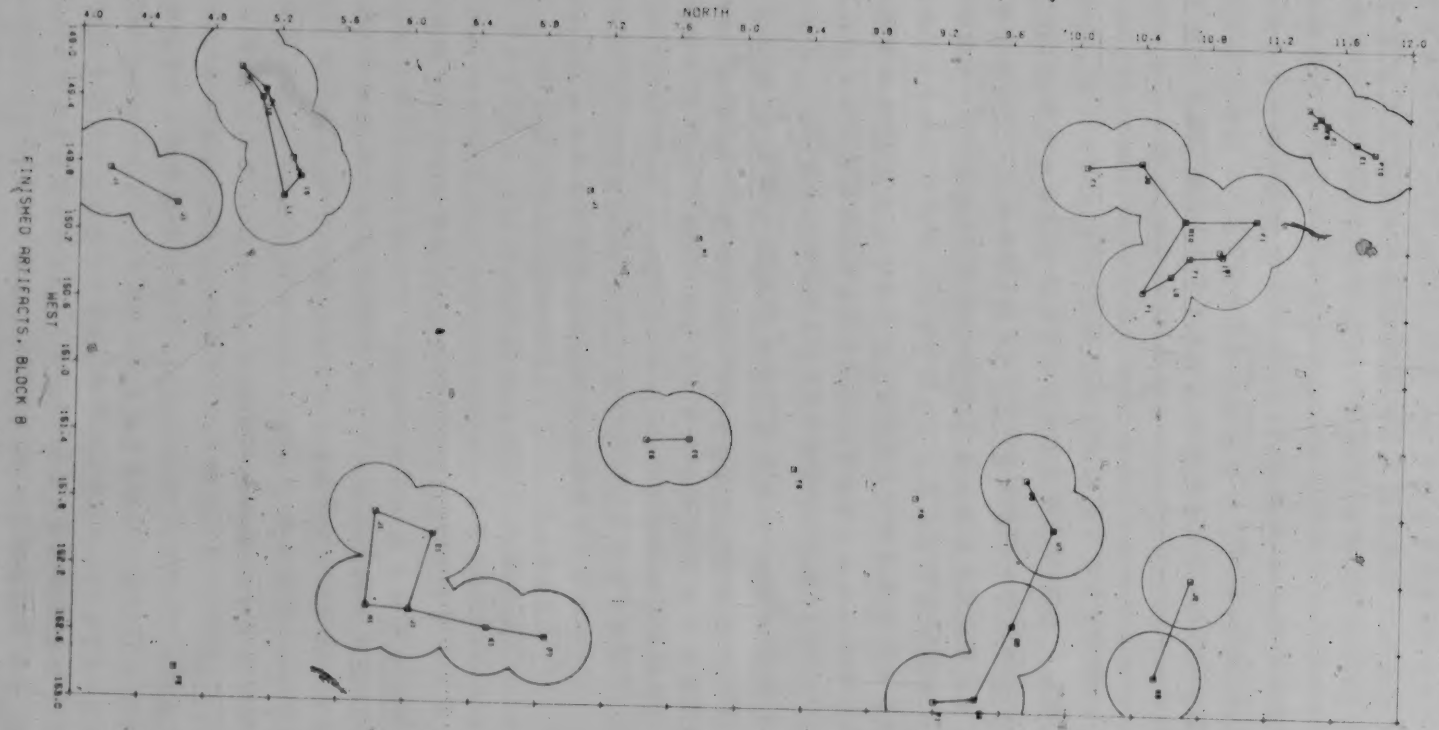

Figure 22. Finished artifacts in Block B with artifacts which are less than the cut-off distance linked by lines. Circles with a radius of the mean nearest neignbour distance (observed) have been drawn about each of the outlying artifacts. This provides a graphical method of cluster definition.

Why not extend the method by using cut-off distances from order neighbours? Practical difficulties are encountered almost immediately: as the cut-off distance rises in value (with each order neighbour) defining circles overlap increasingly. In effect, artifacts become candidates for more than one cluster, and we need some set of rules for assigning individuals to clusters.

Taxonomic Methods

This last difficulty can be viewed as a taxonomic problem in which we wish to know where a candidate OTU should be assigned. In fact, the method described above, which uses a simple cut-off distance, resembles single-linkage SAHN (Sequential, Agglomerative, Hierarchic, Nonoverlapping) methods (nearest* or farthest neighbour, for example). Single-linkage methods are plagued by a tendency toward's "chaining" or the formation of long, straggling clusters (Wishart 1975:37). In applying the nearest neighbour derived "cut-off" method to the data at hand, chaining results. The analogy can be carried one step further. The failure of this "cut-off" method to elucidate pattern grain stems from the fact that it is not hierarchic. There is only one level at which fusion can occur (unless order neighbour cut-off distances are used).

The application of a more powerful clustering method should be productive. One such technique is Ward's method. Ward (1963) proposed that at any stage of taxonomic analysis, the "loss of information" which results from hierarchically grouping point swarms into clusters can be measured by the total sum of the squared deviations of every point from the mean of the cluster to which it belongs. The error sum of squares is defined as the distance from each individual to the centroid of its parent cluster (Wishart 1975:38). When individuals have been grouped into a cluster, the sum of the deviations of the points about the group's mean gives an indication about the cluster's homogeneity. Those two clusters P and Q whose fusion yields the least increase in the error sum are combined (optimizing the error sum of squares objective function). Ward's method, as applied with the CLUSTAN 1C package, finds minimum variance spherical clusters (Wishart 1975:38).

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*Single-linkage nearest neighbour is a clustering method unrelated to spatial analysis.

To be sure, this is an unusual application of cluster analysis and there are difficulties. Although Ward (1963) made no comment on standardizing variables, Wishart (1969:170) feels this is important because

> ...the error sum of squares must be a factor of the variances of the variable distributions, and is, therefore, biased towards variables with high variance. It is, therefore, recommended that the sample coordinates should be transformed to standard form prior to analysis.

The objective of undertaking a cluster analysis of artifact distributions is entirely spatial in nature, however. For this reason, the CLUSTAN option allowing raw continuous data to be filed was used. Standardization could distort actual spatial relationships. Plotting distortion still occurs with procedure SCATTER, although it can be minimized by allowing plot boundaries to be set automatically (compare Figures 6-9 with Figures 23-26). Fixing axis length produces an effect Wishart (1975:92) terms "stretching".

Results

Finished artifact distributions from HkPa 4 were submitted to analysis by Ward's method with procedure HIERARCHY of the CLUSTAN 1C package (Wishart 1975). Only artifact coordinates (south and east measurements) were utilized as variables. With CLUSTAN, the investigator specifies a number of clusters to be formed by the SAHN method chosen. In situations such as Block D, where three basic clusters are clear cut, this presents no difficulty. However, in other instances, the investigator is less certain about the number of spatial clusters involved and can benefit from any understanding of how "natural" a classification of spatial clusters has been obtained.

The MODE procedure in CLUSTAN allows a probabilistic interpretation of a classification. Briefly, probability surfaces surrounding "dense" points in the distributions of items can be assessed for modes. Distributions with single connected surfaces are unimodal, and on probabilistic grounds, it can be argued that the population of items cannot be subdivided into "natural" classes (see Wishart 1975:55 for a complete discussion). Identification of more than one mode is a form of evidence for significant structure in the population of items under consideration, although concepts of significant structure and "naturalness" hold no consensus of opinion in numerical taxonomy (Sneath and Sokal 1973:284). While the CLUSTAN fusion summary table, F-ratios from procedure RESULT, and the results of procedure MODE provide an objective guide to clustering, archaeological judgement must intervene at this point:

1. Specific artifacts may be rejected from a cluster on grounds other than horizontal proximity (e.g., depth).
2. Clusters of two, and perhaps three, artifacts may be fortuitous and are viewed skeptically.
3. Block units or areas of block units may not be considered in instances where cluster overlap and disturbance could figure prominently (e.g., Block A).

Relevant archaeological variables considered in the definition of a cluster included depth below datum, soil horizon, raw material, and artifact class. A detailed analysis of edge wear patterns may be a key to understanding the functional significance of a cluster. For the purposes of cluster definition, similar kinds of edge wear on various artifacts, or a logical sequence of edge wear patterns can be construed as evidence for the temporal relationship of artifacts.

Using this combination of archaeological judgement and objective rules from numerical taxonomy, it is possible to define 18 clusters: 2 in Block A, 5 in Block B, 8 in Block C (West half), and 3 in Block D. These clusters encompassed 182 of the 300 finished artifacts recovered, or over 60%. Plotting with procedure SCATTER is presented in Figures 23-26, Appendix D, while spatial clusters (outlined by convex hulls) are presented in Figures 27-30, Appendix D. The reader is referred to Table 14 for a summary of the artifacts in each spatial cluster. Letters A-D identify the block unit in which the cluster is located. It should be pointed out that Block A is not a clearly aggregated distribution and only two clusters (defined by CLUSTAN and carefully observed in the field) were accepted under the criteria discussed above. The East half of Block C was not analyzed (since it is randomly distributed).

TABLE 14

DISTRIBUTION OF ARTIFACT TYPES IN SPATIAL CLUSTERS, HkPa 4

Spatial Artifact Cluster	Number of Artifacts In Cluster	Artifact Classes													
		E	F	G	H	I	J	K	L	M	N	O	P	Q	U
A1	6	5	0	1	0	0	0	0	0	0	0	0	0	0	0
A2	11	1	4	3	1	0	2	0	0	0	0	0	0	0	0
B1	5	1	2	0	1	0	0	0	0	0	0	0	1	0	0
B2	6	0	3	0	1	1	0	0	0	1	0	0	0	0	0
B3	6	0	2	2	0	0	1	0	0	0	0	0	0	0	1
B4	5	0	1	0	1	0	2	1	0	0	0	0	0	0	0
B5	8	1	1	0	0	3	2	0	1	0	0	0	0	0	0
C1	8	2	3	0	0	0	1	0	1	0	0	1	0	0	0
C2	4	0	0	0	0	0	3	0	0	0	0	1	0	0	0
C3	9	0	3	0	2	2	1	0	0	0	0	0	1	0	0
C4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0
C5	6	2	2	0	0	1	1	0	0	0	0	0	0	0	0
C6	4	1	0	0	2	0	0	0	0	1	0	0	0	0	0
C7	6	0	3	0	0	0	1	0	0	0	2	0	0	0	0
C8	8	3	1	1	0	0	3	0	0	0	0	0	0	0	0
D1	7	2	3	1	1	0	0	0	0	0	0	0	0	0	0
D2	74	29	22	6	0	0	9	3	3	0	0	0	0	0	2
D3	6	1	4	0	0	0	0	0	1	0	0	0	0	0	0

CHAPTER IX.

ANALYSIS OF SPATIAL ARTIFACT CLUSTERS

Summmary Statement

The first three questions posed in the analytical framework cited earlier can now be answered. There were:

1. Are the distributions of artifacts in excavation units random?
2. If artifact distributions in excavation units are not random, how can we characterize these distributions?
3. If artifact distributions are significantly patterned in the direction of aggregation (i.e., they are clustered or clumped), can spatially discrete artifact clusters be segregated?

For the most part, finished artifact distributions are contagious. This is true of Block B, the West half of Block C, and Block D. Block B exhibits moderately intense patterning, and randomness is approached in higher order neighbours. That is, aggregates in this contagious distribution appear to be randomly dispersed. Recalling the results of the Clark and Evan's type test and analysis of the unaltered distribution, it is possible that aggregates tend to occur more regularly spaced than expected. The West half of Block C is marked by somewhat weaker patterning. Again, higher order neighbours are randomly dispersed, suggesting that there is no significant patterning of the aggregates themselves. Patterning is particularly intense in Block D. The large number of artifacts in D2 (and consequently, the large number of small neighbour distances) actually obscures the interpretation of pattern grain by order neighbour statistics. However, the three clusters present seem quite well spaced.

Order neighbour analysis of the East half of Block C reveals that there is no significant departure from randomness. Similarly, the first four order neighbours in Block A are randomly distributed, and the remaining order neighbours are aggregated. Neither of these units were suitable for an attempt to define a series of spatial artifact clusters (although two dense clusters were accepted for Block A).

Total artifact distributions, as analyzed by mean square block analysis and density contouring, show intense patterning in all block units. For both finished and total artifact distributions, the techniques applies suggest a fine-grained pattern with a scale on the order of one half by one half square meters to one by one square meter. These characteristics of the artifact distribution permitted the taxometric definition of spatial clusters and it is now possible to proceed to a more detailed analysis of these entities.

Analysis of Spatial Clusters

The ideal course of action at this juncture would be to further subdivide the clusters defined into roughly synchronous components. In other words, the normal chronological concerns of archaeology can be a by-product of this type of analysis. It would be possible, theoretically, to speak of a "Middle Taltheilei assemblage" which had been derived from clusters tagged with Middle Taltheilei diagnostics. This "tagging" might be of a more indirect nature: a large enough sample of directly tagged clusters might permit the recognition of other regularities in the tagged clusters. These regularities could identify untagged clusters. Unfortunately, this discussion must remain in the realm of conjecture for the present. The sample obtained is too small to attempt distinctions as fine as these. What is more, the data base is further reduced by the problem of random distributions and the possibility of cluster overlap and artifact disturbance.

The thirteen projectile points recovered during the excavation of block units were distributed in the following fashion. More precise typological comparisons of the specimens described below have been made previously (Chapter IV; Ives 1977). Three projectile points occurred in Block A: the basal portion of a stemmed point comparable to MacKenzie Complex and Windy Point Complex materials (suggesting dates of ca. 300 B.C. to A.D. 500), the base of a corner or side-notched point probably of Late Taltheilei (A.D. 800 to A.D. 1750) affinity, and a basally flared lanceolate point of limited diagnostic value. In each case, the specimen is comparatively isolated from other finished artifacts. Therefore, no clusters are tagged and at least two time periods seem to be represented.

The diagnostics recovered from Block B are clearly associated with spatial artifact clusters. (The reader is referred to Table 14 for a summary of the artifact composition of each of the clusters described below.) A distinctive, square-based lanceolate point, which compares faborably with the Middle Taltheilei (A.D. 150 to A.D. 600) specimens Gordon (1976) describes, is noted in B2. Cluster B1 contains a quartzite core distinguished by globular spots of a white impurity. This feature is uncommon at the Eaglenest Portage site, and since associated debitage and other finished tools in both clusters share this impurity, it is suggested that these two clusters are temporarily related. Two highly similar side-notched projectiles and the base of a notched point are noted for cluster B5. Again, Late Taltheilei (A.D. 800 to A.D. 1750) affinities are suggested. It seems likely that three of the spatial clusters in Block B (B1 and B2 on the one hand and B5 on the other), belong to different time periods.

Projectile points recovered in the West half of Block C are also associated with spatial clusters. A black chert side-notched specimen and a basally fragmented but notched quartzite specimen were recovered from cluster C3. Late Taltheilei affinities are most likely. Black chert debitage was common in the general area and some finished artifacts in cluster C4 were of black chert. There is some indication, then, that C3 and C4 are temporally related. A single basally flared specimen came from C5. Tentative comparisons have been made with a Karpinsky site specimen (A.D. 880). No temporally diagnostic items were recovered from Block D.

The remaining five diagnostics all come from the East half of Block C, an area marked by a random distribution of finished artifacts. Four of these diagnostics are strongly reminiscent of the Frank Channel Complex (A.D. 1300 to A.D. 1500), and the fifth specimen, another small side-notched point, is also Late Taltheilei (A.D. 800 to A.D. 1750). Therefore, there are grounds for the suggestion that all of the artifacts in the East half of Block C are temporally related. Indeed, I am prepared to argue that all of the diagnostics from Block C in its entirely are broadly contemporaneous (i.e., Late Taltheilei).

The comparisons made above substantiate the fact that the 18 spatial clusters defined come from different time periods. Unfortunately, only four clusters are directly tagged with diagnostics, and there is little point in attempts to subdivide clusters into temporally related "components". However, another useful perspective can be adopted. The spatial clusters are a sample of archaeological units related to the behavioral processes enacted at the Eaglenest Portage site through time. Seen in this light, it is possible to ask if there are regularities associated with the long term utilization of the site which are manifested in spatial clusters. This is a pertinent question in that the probable ecological orientation of site use, the exploitation of fish resources, may have been fairly constant. With this perspective in mind, I will now attempt to answer the final question of the analytical framework. Are artifact types differentially associated in these clusters and are there cluster "types"?

Spatial Association of Artifact Types

The spatial clusters of artifacts delimited in the last chapter can now become the unit in which the association of artifact classes is assessed. Normally, chi-square values from 2 by 2 contingency tables could be used to test association. However, a sample of 18 clusters is too small for this application (Mueller-Dumbois and Ellenberg 1974:239-240). For this data, Sorenson's coefficient of similarity, which gives more weight to matches than does the Jaccard coefficient, is applied (Sneath and Sokal 1973:131):

$$S_D = \frac{2a}{(2a + b + c)}$$

where a represents the number of clusters in which both of the artifact classes under consideration occur at once, b the number of clusters in which the first class of artifacts occurs by itself, and c the number of clusters in which the second artifact occurs by itself.

A matrix of coefficients of similarity for the seven more common classes of finished artifacts in the clusters is presented in Table 15. Only retouched flakes, used flakes, and endscrapers show strong association, although cores, split pebbles, and large bifaces show some moderate values. The ordered matrix of Pearson product-moment correlation coefficients (Sneath and Sokal 1973:138) in Table 16 reveals strong spa-

TABLE 15

MATRIX OF SØRENSON'S SIMILARITY COEFFICIENTS FOR FINISHED ARTIFACTS, HkPa 4

	Retouched Flakes	Endscrapers	Used Flakes	Cores	Split Pebbles	Large Bifaces	Projectile Points
Retouched Flakes	1.00	0.77	0.71	0.55	0.48	0.42	0.44
Endscrapers	0.77	1.00	0.55	0.33	0.47	0.40	0.40
Used Flakes	0.71	0.55	1.00	0.44	0.56	0.50	0.25
Cores	0.55	0.33	0.44	1.00	0.31	0.00	0.36
Split Pebbles	0.48	0.47	0.56	0.31	1.00	0.20	0.00
Large Bifaces	0.42	0.40	0.50	0.00	0.20	1.00	0.25
Projectile Points	0.44	0.40	0.25	0.36	0.00	0.25	1.00

tial association between endscrapers, used flakes, split pebbles, and large bifaces. Weak positives and negatives characterize values for cores and projectile points. Pearson product-moment correlation coefficients can be tested for significance by a t-distributed random variable (Harnett 1975:400) and coefficients significant at the 0.01 level are grouped in Table 16. Despite the fact that spatial clusters from different time periods have been lumped together, the group of artifacts described above appear to be regularly associated in a highly significant fashion.

Taxonomic Analysis of Spatial Clusters

The attempt to discern regularities amongst clusters can take a different form. Spatial clusters themselves can be submitted to cluster analysis. Only numbers of artifacts per artifact class were utilized as data, providing an idea of the "artifact structure" of each spatial cluster. This phase of analysis is a cursory treatment. A lengthier attribute list, including raw material, data on edge wear pattern, intracluster dispersion, and so on, would yield a much more meaningful classification of spatial artifact clusters. Ultimately, cluster analysis might lead to the identification of spatial cluster "types" which in turn might have been generated by particular kinds of behavior.

The 18 spatial clusters defined were analyzed with Ward's method in the CLUSTAN 1C package. Raw data have already been presented in Table 14. A dendrogram for the spatial clusters is shown in Figure 31. Application of procedure MODE indicates four modes.

Spatial cluster D2 is distinguished at all but the final hierarchical level. As discussed in the next section, this dense concentration of large flakes and finished artifacts was unique at HkPa 4. B2 and C6

TABLE 16

ORDERED MATRIX OF PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS, HkPa 4

	Endscrapers	Used Flakes	Retouched Flakes	Split Pebbles	Large Bifaces	Cores	Projectile Points
Endscrapers	1.00	0.96^{**}	0.94^{**}	0.91^{**}	0.87^{**}	-0.29	-0.05
Used Flakes	0.96^{**}	1.00	0.92^{**}	0.83^{**}	0.86^{**}	-0.24	-0.15
Retouched Flakes	0.94^{**}	0.92^{**}	1.00	0.84^{**}	0.87^{**}	-0.14	-0.11
Split Pebbles	0.91^{**}	0.83^{**}	0.84^{**}	1.00	0.66^{**}	-0.32	-0.42^{*}
Large Bifaces	0.87^{**}	0.86^{**}	0.87^{**}	0.66^{**}	1.00	-0.16	0.06
Cores	-0.29	-0.24	-0.14	-0.32	-0.16	1.00	0.15
Projectile Points	-0.05	-0.15	-0.11	-0.42^{*}	0.06	0.15	1.00

* Correlation coefficient is significant at the 0.05 level

** Correlation coefficient is significant at the 0.01 level

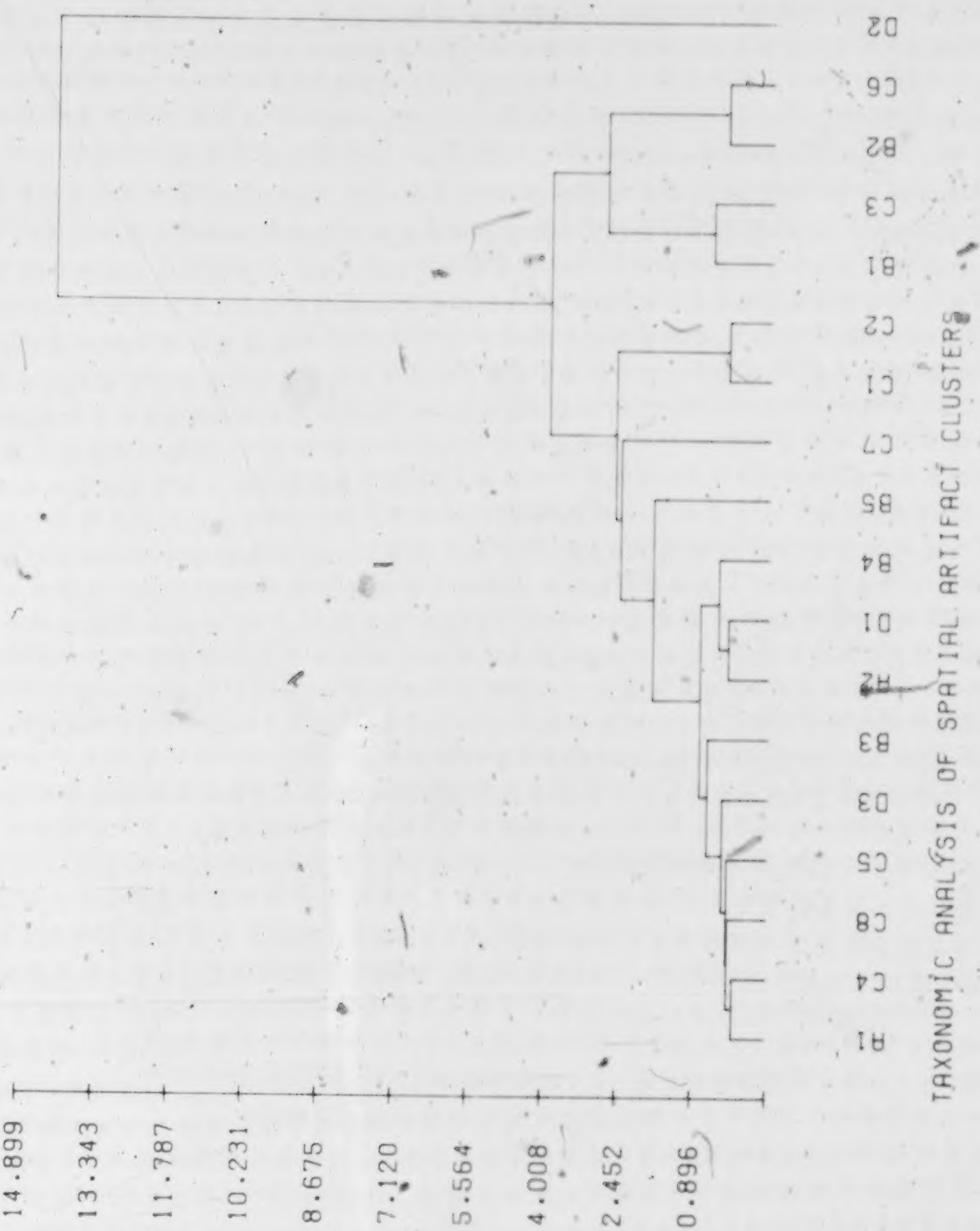

Figure 31. A dendrogram from the cluster analysis of the artifact structure of 18 spatial clusters defined at HkPa 4. Ward's method as applied in the CLUSTAN package was utilized.

seem to be distinguished by the presence of single spall tools in each, while B1 and C3 each have a hammerstone. In the same vein, spatial clusters C1 and C2 both have a single bone tool, and C7 has two cobble tools. The remaining ten clusters are dominated by the artifacts showing strong spatial correlation amongst themselves: retouched flakes, endscrapers, used flakes, split pebbles, and large bifaces.

No great significance is attached to the classification of this small sample, principally because so many unincluded attributes would be useful. Nevertheless, the dendrogram in Figure 31 has another interesting aspect. The artifact structure of each cluster does provide clues to the primary functional orientation of each cluster. For example, a cluster consisting exclusively of cores, hammerstones, anvils, and split pebbles indicates a primary emphasis upon lithic manufacture. A cluster consisting solely of endscrapers seems oriented towards other activities (such as woodworking or hide preparation). Naturally, admixture of artifact classes is the common state of affairs. Using Table 14 as a guide, clusters exhibiting lithic manufacture as opposed to other activity clusters are segregated in Figure 31. Clusters A1, B3, B5, C1, C2, C4, C5, C7, C8 and D3 are dominated by classes of tools not associated with lithic manufacture. Clusters A2, B1, B2, B4, C3, C6, D1 and D2 show an admixture of nonmanufacturing and manufacturing tool classes (cores, split pebbles, hammerstones). Therefore, the classification obtained does indicate a dichotomy in cluster function.

Spatial Clusters and Generative Processes

Artifact distributions reflect not so much "fossilized" social systems as the unique combination of biophysical and cultural processes active in the deposition of discarded and lost tools. To an understanding of prehistoric behaviour, these processes are of little intrinsic interest in themselves. They do, however, effectively obscure the archaeologist's perception of prehistoric socio-economic activity. In general terms, then, we are interested in the extent to which the salient features of prehistoric human activity (above and beyond the simple disposal of material remains) are visible in the spatial organization of artifact relationships at this site. More specifically, how often do artifact clusters equate with the remains of expediently produced activity sets from activity areas?

To investigate the relationship between spatial structure and more substantive social and economic processes, a spatial snalysis can emphasize the use of correlation and association matrices. With this use in mind, Speth and Johnson (1976) have suggested several general types of spatial patterns the archaeologist can expect to encounter:

1. Dispersed activity areas are the scene of single activities and groups of related activities corresponding to artifact distributions which are partitioned into spatially distinct units or loci.
2. Agglomerated activity areas are marked by limited spatial dispersion of artifacts and a higher degree of distributional overlap within a more intensely used location.
3. Agglomerated disposal areas result from the collection of artifacts through sweeping or dumping into relatively compact refuse areas.
4. Agglomerated storage areas occur when items used in a wide range of activities are stored together at loci such as residence units, but are abandoned prior to use.
5. Scattered disposal areas arise if artifacts are haphazardly tossed beyond the area of intense activity. Some sorting on the basis of size might occur.
6. Admixtures of these various patterns are to be expected, probably quite commonly. (Speth and Johnson 1976:50-52).

Only in the case of dispersed activity areas could the archaeologist be confident that the spatial association of different tool types provided a realistic picture of the functional relationship once existing between them. A correlation matrix dominated by strong positives and strong negatives is predicted. Each of the agglomerated patterns would be expected to yield a matrix with almost exclusively positive values. Still, if more than one type of patterning appears in a distribution, artifact pooling occurs in a fashion that makes attempts to illuminate the functional relationship between artifacts misleading (ibid.).

It can be grasped immediately that the interpretation of spatial patterning from correlation matrices is at best hazardous. So small a matrix as the one presented in Table 15 is hardly amenable to a rigourous interpretation. If we were to characterize it, however, the absence of strong negatives and predominance of weak through strong positives implies some form of agglomerated patterning, unless, of course, the seven tool types tested were not functionally specific and occurred at dispersed loci anyway. In point of fact, Speth and Johnson (1976) list a host of technical problems in the use of correlation coefficients, among them, 0-0 cells (discussed below), variation in the frequency of items per cell, attenuation, and sampling error. The reader is referred to this work for a complete discussion.

On the other hand, direct spatial analysis of distributions and their characteristics has a number of positive technical advantages. The primary advantage is the fact that the distribution is the study topic, and there is no need to infer a spatial pattern from a matrix. Other difficulties are avoided. 0-0 cells refer to grid units in which neither of the artifact classes under consideration occur (Speth and Johnson

1976:38-40). As the proportion of 0-0 cells in a sample increases, correlation coefficients can be transformed in value radically. The effect of 0-0 observations is closely related to the size of the grid units employed; altering grid unit size will alter the proportion of 0-0 cells. Making the spatial cluster the unit of correlation provides some control over this problem. Here, the proportion of 0-0 observations is a tangible characteristic of the distribution, one that is not modified by the extraneous factor of grid size. 0-0 observations allow recognition of real variability in the compostion of an archaeological entity, the spatial cluster of artifacts.

The phenomenon of 0-0 cells is only part of a larger problem archaeologists consistently ignore. Excavation almost always makes use of grid units (traditionally one meter or five foot squares). Yet, the effect of the size of the grid units upon the spatial association of artifacts and the variance between units is seldom considered. Needless to say, for a given scale of pattern, increasing grid unit size can change a strong negative correlation into a strong positive correlation. If the actual unit of association is the spatial cluster of artifacts, the techniques presented here are capable of defining that cluster at a good approximation of its true size (as long as it is not larger than the sample unit itself). Association is then tied to the reality of the spatial cluster, and not to the transient phenomenon of grid unit size. Some understanding of the scale of patterning in artifact distributions is critical to the choice of an appropriate excavation unit when large block units are not employed.

Since only a few artifacts occur with sufficient frequency to be used in correlation matrices and since severe methodological and theoretical flaws drastically influence that approach, we turn to the information that can be gleaned from the direct analysis of artifact distributions. Distinctions based on the artifact structure of each cluster were discussed in the last section. Spatial cluster D2 in Block D is unequivocally separated from the other clusters in Figure 31. This dense cluster of 74 finished artifacts and some 270 other large flakes and fragments is unique. The ratio of debitage to finished artifacts (roughly 4:1) stands in direct contrast to that of the entire site (22:1). More tool types than usual are represented. Materials that are comparatively rare, Beaver Creek Quarry quartzite (roughly 5% over the whole site) and black chert (roughly 3%), are present in unusually high quantities (21% and 6% respectively). Taken together, these facts make it reasonable to propose that D2 is an artifact storage area--either an unrecovered cache, or a complete group of artifacts accidently lost in some other way.

The vicinity of the site in which Block D is located is noteworthy. The three finished artifact clusters coincide with debitage concentrations, but there is comparatively little debitage. The last 17 meters of Transect II, which runs through the area, show an all artifact to finished artifact ratio of 3:1. Within Block C, this ratio is 6:1. Such distinctive artifact relationships (highly discrete clusters with low debitage content) warrant the speculation that this microgeographic area of the site was utilized differently. In that Block D is situated at the head of the narrow rocky stream running past the site, the first practical upstream location for weir building, a focus on fish processing may be suggested. This would be an instance of greater task orientation as opposed to lithic manufacture.

By and large, however, finished artifacts do show a strong association with debitage concentrations. This suggests an intimate relationship between lithic manufacture and cluster formation and less emphasis on nonmanufacturing tasks by themselves (butchering for example). Making this conclusion seems to negate the segregation of activity vs. lithic manufacture clusters argued for earlier. However, the concentrations of retouch flakes and bifacial thinning flakes common at HkPa 4 probably reflect debris associated with tool maintenance during use. The interrelationship between lithic technology and other activities at the site takes on an added complexity. There seems to be an intimate relationship between both tool fabrication and tool maintenance and the application of tools in other activities. Further research could profitably illuminate this distinction by focusing on the debitage associated with spatial clusters.

The spatial relationship between lithic manufacture and tool use, I would suggest, implies a fundamental tendency towards expediency in tool use and discard (rather than curation) at the manufacturing locus. This can demonstrated with a few examples. Small concentrations of proximal fragments of side-notched projectile points are not unusual. These are often associated with complete specimens (test pits, B5). Areas like this may indicate loci for replacement of broken points and rehafting. Two irreparably broken side-notched projectile points in C3, associated with similar lithic debitage, cores, and a hammerstone, might very well be present through discard due to breakage at the point of manufacture; completed retouched flakes and an endscraper are present also, however. Similarly, cluster B1 contains a hammerstone and a core as well as used and retouched flakes. Even though there are three split pebbles and one core in A2, the remaining seven artifacts include endscrapers, retouched flakes and a used flake.

It can be postulated, then, that artifact clusters could be formed not only from discard during nonmanufacturing tasks, but also from the simple localization of lithic tool production and the subsequent loss or rejection of artifacts. It should be noted that many artifacts exhibit use wear, even if associated with cores and hammerstones; this is taken as evidence that clusters are not wholly formed as the result of manufacturing procedures. I suggest that loci for tool manufacture and tool use largely correspond at the Eaglenest Portage site.

It is clear that spatial clusters connected with artifact storage and manufacture are present. Perhaps dispersed activity areas associated with the debitage resulting from manufacture generated most clusters. This assertion requires further research. Certainly the covariance of nonrandomly distributed artifacts is not a straightforward proof of functional compatibility or relatedness. Association or correlation might be related equally to storage and transport practices or manufacturing techniques. Thus, the archaeologist is not afforded a clear view of higher order social processes.

Spatial Artifact Cluster Dispersion

The dispersal of spatial artifact clusters themselves opens the way to interesting problems and warrants speculation. The same underlying assumptions concerning regularities in site use through time can be made. Patterning in the distribution of clusters could take two forms. The small scale aggregation that has been noted suggests to me that spatial artifact clusters share systematic correspondences with basic units of activity once carried out at the Eaglenest Portage site. The distribution of clusters has special reference to the organization of these activities. If the patterning of clusters is compound--for example, if the clusters themselves are aggregated--the nature of this pattern can reveal aspects of the socio-economic organization of groups once exploiting the site. To be more specific, compound patterning might provide evidence related to the composition and size of the groups exploiting the site and the duration and season of occupation. At a larger scale, differences in the spectrum of compound patterning found at the site might constitute evidence for the differential use of various microgeographical areas.

Given that the Beaver Indians provide a useful model in this instance, there are several expectations for spatially patterned activity at HkPa 4. Ridington (1968:32-33) posits a seasonal cycle of aggregation and dispersion of Beaver bands. I have suggested that a likely ecological strategy for the use of HkPa 4 would be the exploitation of spring fish runs followed by the hunting of dispersed big game mammals on the uplands. A summer congregation of the wutdunne (local band) would have been possible at this site, and several family units (perhaps 30 or more persons) may have gathered (ibid.:41). Alternatively, if winter occupation (as an emergency resort to fish lakes) were the case, a small family unit might have been present at the site. With this scenario, summer occupation should be marked by the creation of spatial clusters over an extensive area, while winter occupations might create smaller, dispersed habitation areas. This tells us comparatively little about the patterning within an area of summer or winter occupation. Two possibilities are envisaged. The summer-oriented researcher often finds it easy to forget the constraints that the severe winter cold of northern biomes imposes upon human behavior. It seems reasonable to suggest that winter activities would tend to agglomerate in and around available shelter, usually a tipi (Goddard 1916:210). Large aggregates or contagiously distributed clusters are predicted for areas of winter occupation. Summer camping would require less in the way of shelter--simple brush lean-to structures were fashioned in temporary camps (ibid.)--and activities could be performed conveniently at dispersed loci. In areas of summer occupation, well-spaced artifact clusters are predicted.

The tendency towards uniform patterning in higher order neighbours in Block B suggests that spatial artifact clusters are farther apart than would be expected under the hypothesis of randomness. Randomness is observed for higher order neighbours in the West half of Block C, and the three artifact clusters in Block D appear well spaced. Patterning in these units might therefore be interpreted as evidence of spring or summer occupation. The East half of Block C, on the other hand, could be a large synchronous aggregate indicative of winter occupation. Diagnostics confirm at least rough synchroneity. The same conclusion might be reached for Block A.

The difficulties with this discussion should by now be manifest. They do bear emphasis. No temporal distinctions have been made between clusters. This is clearly an error in Block A and Block B where different time periods are represented. In the case of Block B, the error is not serious. It means that temporally related clusters in that area were actually even farther apart. However, the potential for error is great; to discriminate cluster patterning, temporal control is a necessity.

Different patterns of clusters controlled by different or changing variables (e.g. season of occupation) could be "overlaid" time and again at HkPa 4. The resultant cumulative pattern probably has little reference to the original processes of cluster dispersal. It is thus impossible to speak of regularities in the distribution of spatial clusters through time without temporal control. In Figure 32, an aggregated pattern of clusters was drawn upon a regular pattern in such a way as to create an aggregated pattern overall. This hypothetical situation has an analog in the event that different kinds of spatial organization of activity are represented in the two millenia of prehistory at HkPa 4. Figure 32 also draws attention to the smallness of the excavation units employed. I believe I have only effectively detected a single small scale of pattern. Excavation blocks provide but a glimpse of patterning over large areas.

No specific reference to cluster function has been made. The dispersion of clusters used for storage has one implication, and the dispersal of clusters from activity areas has another. Even if most clusters pertain to activity areas, proxemic behaviour could exert an important influence. What if interpersonal interactions were always widely spaced? Goddard (1916:221-222) does note some patterns of social avoidance among the Beaver. The distribution of artifact clusters might always be highly dispersed, winter or summer. This situation would contrast with the agglomerated camps and closer spacing behaviour evident amongst the South African Bushmen (Wiessner 1974).

It is my firm conviction that sampling units 4 to 8 times the size of those in use, as well as as a means for discerning the temporal relationships of all (or at least the great majority) of the clusters in-

A HYPOTHETICAL COMPOSITE DISTRIBUTION OF REGULAR AND AGGREGATED CLUSTERS

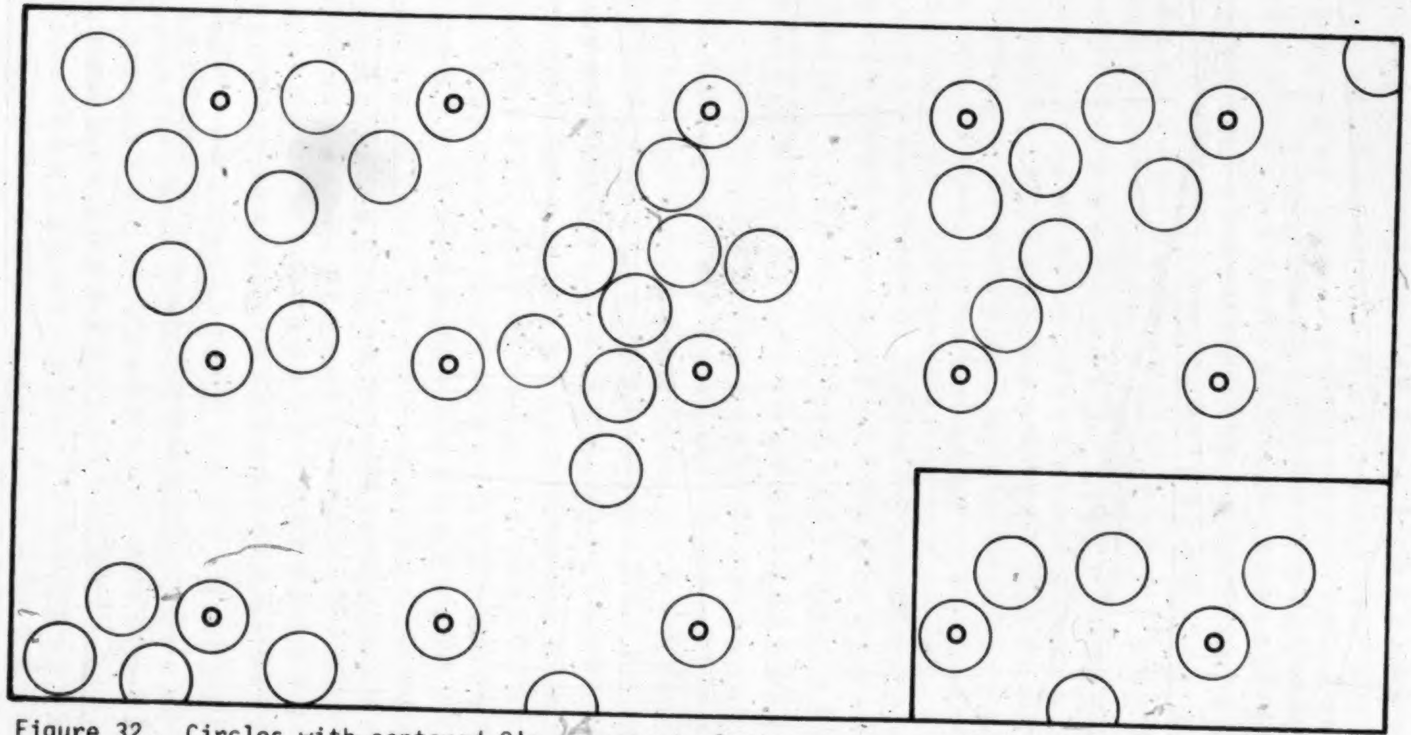

Figure 32. Circles with centered O's represent clusters arranged in a regular pattern. Blank circles were then superimposed. These have a contagious distribution. The overall pattern has the appearance of aggregation. If spatial artifact clusters from HkPa 4 are analyzed without reference to chronological differences, descriptions of cluster patterning in space might very well be fallacious since the patterning present may have a composite (diachronic) origin. Sample units used at HkPa 4 probably cover no more of the total distribution than does the area blocked off in the lower right hand corner.

volved, are necessary adjuncts of any attempt to relate the spatial patterning of clusters to socio-economic organization. These provisos can be at least partially met with adequate research design, and in that case the archaeologist does have access to some evidence pertinent to these more fascinating topics. The fundamental complexity of the processes contributing to the archaeological record must never be underestimated, however.

CHAPTER X.

CONCLUSIONS

Formation of the Archaeological Record at HkPa 4

Several cultural and ecological features external to the spatial analysis are of general import to the archaeological record. Given the current status of research conducted in northeastern Alberta, we can tentatively identify the following broad scale processes operative in the history of the site:

1. The Beaver Indians are the probable prehistoric inhabitants of the study area during the recent occupation of the site.
2. Site location suggests an emphasis on a fish resource. Modern ecological evidence favours spring occupations associated with fish spawns followed by summer hunting of moose, woodland bison, and woodland caribou. Other exploitative strategies cannot be ruled out.
3. Natural disturbance of artifacts likely does not contribute to significant horizontal artifact movement.
4. Typological comparisons of diagnostic artifacts indicate that:
    a. While there is no cultural or natural stratigraphy, HkPa 4 is a multicomponent site and at least 2,000 years of prehistory is represented.
    b. Contemporaneous or chronologically separated utilization of the site by Plains affiliated groups cannot be substantiated on the basis of current evidence.

With specific reference to hypotheses advanced earlier, order neighbour analysis of the finished artifact distribution in Block A reveals a slight tendency towards aggregation only in the fifth through tenth nearest neighbours. The distribution is not clearly aggregated and no concerted effort to form spatial clusters is made. This unusual result for order neighbour analysis can probably be attributed to small sample unit size. Artifact density (for both finished artifacts and debitage) is high and cluster overlap is strongly suspected. Although diagnostics do not appear to be associated with any finished artifact concentrations (including the two dense clusters which were accepted), the presence of a Mackenzie or Windy Point Complex stemmed specimen and the base of a side-notched point suggests that cluster overlap is likely diachronic.

Artifact distribution in Block B is nonrandom and exhibits strongly aggregated patterning. Finished and overall artifact density is much lower than in Block A, and spatial clusters are discrete. The clusters themselves are either randomly or regularly distributed, although this item of data is of limited use since both Middle and Late Taltheilei time periods are represented in three of the five clusters defined. In this sense, spatial clusters are isolated.

The artifact distribution in the East and West halves of Block C appears to be different, and order neighbour analysis confirms this. The East half shows no significant patterning; the diagnostics recovered are contemporaneous and suggest the Late Taltheilei period (in particular, the Frank Channel Complex). No attempt to form spatial clusters is made. On the other hand, the West half of the distribution is weakly to moderately aggregated and 8 spatial clusters are defined. Diagnostics indicate broad contemporaneity (Late Taltheilei), although it is doubtful if more precise synchroneity exists. Clusters appear to be randomly distributed. In all of Block C, overall and finished artifact density is high, although not quite as high as in Block A.

Block D shows intense clumping, with highly discrete spatial clusters. Unfortunately, no diagnostics were recovered, and the temporal relationship between the three clusters is not clear. Clusters appear well spaced. With the exception of the D2 area, overall artifact density in Block D and the surrounding area is very low.

In summary, for the majority of the sample, small scale, discrete clusters are detected by spatial analysis. Block A is an instance of possible diachronic cluster overlap and the East half of Block C appears to be a large synchronous aggregate. In general, there is a tendency towards the random or regular dispersal of clusters. Within the 18 spatial clusters described above, endsrapers, retouched flakes, used flakes, split pebbles, and large bifaces are regularly and significantly associated. Projectile points and cores do not show strong negative or positive association. At the same time, an examination of the artifact structure of these clusters suggests the existence of storage, lithic manufacturing, and other activity oriented cluster types.

It is clear that the distribution of artifacts on the site is significantly structured. It is the assertion of this thesis that organized human behavior created the nonrandomness observed in these distributions, and I believe the patterning which has been demonstrated shares systematic correspondences with extinct generative processes. That is not to say that direct relationships between the archaeological record and group maintenance or ecologically extractive tasks are available for analysis. Nevertheless, the small scale aggregation noted allows the interpretation of spatial artifact clusters from the perspective of basic episodes of activity once carried out at HkPa 4.

Intuitively, my impression of the archaeological literature concerning activity sets and activity areas is one in which the researcher attempts to reconstruct tool kits for what I have termed "other activity oriented tasks". The small scale of clustering, the artifact structure of clusters, and the interrelationship between finished artifact clusters and debitage suggest to me that the procedures of lithic manufacture played an important role in the spatial structuring of artifact distribution. Tool fabrication and maintenance may have been the crucial generative processes leading to the nonrandom distributions present, even though other finished artifacts associated with clusters appear to have been used.

I have argued that the problem of small sample unit size and the lack of control over the temporal and functional identity of clusters obscures the archaeologist's conceptualization of prehistoric socio-economic organization. Because of these constraints, it is necessary to speculate that the spacing of clusters may indicate more frequent summer occupation of the site. On ethnographic grounds, this suggests the presence of larger bands at the site. The large aggregate in the East half of Block C may be more indicative of winter occupation by a smaller family unit.

With respect to the nature of the assemblage recovered, finished artifacts are dominated by rudimentary flake tools such as used and retouched flakes. The abundance of used flakes, retouched flakes, end-scrapers, and split pebbles, plus the fact that these artifacts "structure" the distribution, leads me to conclude that they are expediently produced and discarded. Somewhat rarer items in the assemblage, cobble and spall tools for example, were not necessarily curated. Lower frequencies in this case could be proportional to the number of these items produced and used at the site. Certainly, modern ethnographic evidence from New Guinea (White 1968) highlights the significance of unaltered flake tools (which might even go undetected archaeologically) in artifact assemblages. Particularly if the occupation of the site has been associated through time with the exploitation of a fish resource, a very simple flake technology would be more than adequate.

The regular spatial association of several artifact classes in the chronologically "lumped" sample of clusters implies genuine consistency in basic lithic technology. While this feature might be related to exploitative strategies specific to HkPa 4, I feel that consistency through time is of broader significance to northern Alberta archaeology. How much change in lithic technology is manifested in artifact assemblages from this region over the last 2,000 years?

Methodology

There is no question that the methodology exists to carry out an analysis of this type, and that the techniques of spatial analysis in general are readily applied to archaeological data. I prefer to distinguish between spatial analysis by more indirect routes, such as the interpretation of correlation matrices, and the direct statistical characterization of a distribution. I have already pointed out that spatial patterning is inferred from a correlation matrix, and will confine my remarks to the techniques of direct spatial analysis. While the methods discussed here are adequate, refinements are both possible and desirable.

Order neighbour statistics provide useful information about both pattern grain and intensity. The calculations are not prohibitively complex. However, border effect is a crucial problem which must be solved. Point rejection methods are unsuitable because they distort results, and the method suggested by Clark and Evans is wasteful of data. The addition of random borders does appear to be a viable alternative, and future research should be directed at the most satisfactory method of generating the border. In general, I think distance methods are well suited to the low density distributions archaeologists often work with. However, order neighbour statistics are strongest in the consideration of pattern intensity; information about pattern grain or scale is easily obscured by denser aggregates such as cluster D2.

On the other hand, mean square block analysis has great potential in the study of different pattern grains and patterning in the distribution of clusters themselves. Unfortunately, interpreting the statistical significance of mean squares or mean square/mean ratios is at best difficult. A greater number of larger sample units would allow an evaluation of consistency in mean square peaks, the traditional approach in plant ecology. Perhaps more time consuming but statistically independent samples made with different-sized grids should receive more serious consideration. In a recent article, Mead (1974) outlined a fully [illegible] randomization test based on the division of contiguous grid totals into [illegible] half totals (thus having the same format as mean square block analysis). This approach definitely merits attention from archaeologists dealing with a small number of sample units.

Research designs permitting the application of both quadrat and distance methods are desirable in that technical and theoretical strengths can complement each other. Cluster analysis of artifact coordinates is an unusual application, and further experimentation is necessary to confirm its validity. However, it, like mean square block analysis and nearest neighbour analysis, is an objective technique. The need for objectivity in the interpretation of distributions cannot be overstressed. The more information acquired about a distribution, the greater becomes the potential for conflicting subjective evaluations. The use of cluster analysis in this fashion provides an objective set of rules by which artifacts are grouped. This is an essential first step prior to any modifications the archaeologist might judge to be necessary.

Spatial analysis does not greatly tax archaeological field methodology. As discussed in Chapter V, a different sampling strategy is often required. However, excavation techniques need not be altered radically. It has been my experience that all artifact proveniences are frequently recorded by archaeologists. It seems to me that spatial analysis has the capability of answering many of the more interesting questions archaeologists ask themselves. Too often, a great deal of information about horizontal distribution is collected and left unused. While the intent to provide records useful to future workers is laudable, the techniques are at hand to utilize this data now, and their application should be commonplace.

Sample Size and Sample Units

The smallness of both sample size and sample units has had an important bearing upon the results I have presented. This is a reflection of practical contingencies and does not imply shortcomings in the general aims of the research design proposed here, except in that a large sample is required to fully test the hypotheses presented. Only four excavation units were completed. Although it is hoped that decisions concerning the location of excavation units makes the sample representative, the sampling strategy was nonprobabilistic. A higher sampling intensity of randomly selected units would improve the accuracy of the sample.

As I have noted, areas with high densities of artifacts are prone to the effects of cluster overlap and natural disturbance. The data base available for analysis is inevitably further reduced (by roughly a third in this case) by these complications. In addition, only four diagnostically tagged clusters are present. Projectile points are not overly common (I am not willing to concede this is simply the result of curation) at the

Eaglenest Portage site, and there is a measure of uncertainty in locating them (as a matter of chance) which further reduces the number of chronologically places clusters.

In this way, the small sample size hinders the final stages of analysis. Taxonomic analysis of clusters and the analysis of association within clusters actually pertains to regularities in site use over a considerable period of time. As mentioned previously, a large sample of directly tagged clusters ultimately might permit the recognition of stylistic and technological attributes which are also temporally sensitive and could date clusters in the absence of diagnostics. Even if this proved impossible, the weak negative and positive correlation coefficient values for projectile points hints that a large sample of directly tagged clusters from a given time period might be informative in terms of our knowledge of associated finished artifacts.

On another level, there does seem to be evidence for different cluster functions. Some types of clusters, for example, storage areas such as D2, are not especially informative about the functional association of artifact classes or the dispersion of activity areas over the site. Again, a larger sample might be subdivided into categories such as "activity sets" prior to subsequent phases of analysis (e.g., spatial association of tool classes).

It was recognized from the beginning that the excavation units were rather small and were capable of detecting only small scale patterning. This is why I have referred to acquiring a "glimpse" of the spatial organization of artifacts at HkPa 4. Although interpretation is somewhat speculative, large scales of patterning do appear to be present. 4 by 4 meter units are inadequate, and 4 by 8 meter units are barely suitable. 8 by 8 and 16 by 16 meter units will provide a better conceptualization of multiple scales of patterning. This in turn would yield data pertinent to the reconstruction of social organization and the differential use of various site areas.

Implications for Future Research

The basic approach in this study has concerned the identification of spatially discrete loci for finished artifacts. This has a number of advantages and disadvantages for not only Boreal Forest archaeology, but archaeology in general. The approach yields a middle level archaeological unit or entity, the spatial artifact cluster. A unit of this nature is of particular archaeological interest because its attributes can be conceptualized in terms of an episode of activity.

More specifically, two difficult problems with archaeological data are avoided. First, when the scale of patterning in a distribution is unknown, it is difficult to select an appropriate grid size for the analysis of spatial association. Because the cluster of artifacts can assume any size smaller than the sampling unit, the analysis of spatial association in clusters does not introduce spurious effects of this type. Second, the assumption that all or even most tool classes are functionally specific has not been tested adequately (Speth and Johnson 1976:51). The correlation matrix constructed here is dominated by weak and strong positives, and this is some indication that the artifacts involved are not task specific. The fundamental problem of "activity indicators" or "functional artifact categories" remains a poorly explored aspect of archaeology (cf. Krause 1977:292). White (1968) goes so far as to suggest that the criteria archaeologists use to recognize tool classes, criteria as basic as size and shape, may not accurately separate tools into functional groups. When seen in this light, the spatial analysis of all finished artifacts at once still yields primary information pertinent to spatial structure, while the consideration of individual artifact classes can fall prey to our poor understanding of artifact function.

The whole topic of artifact taxonomy necessarily has been ignored, although the manner in which finished artifacts are classified has important implications in spatial analysis. For example, the character of spatial association amongst artifact classes is influenced by the way in which the assemblage is subdivided. The "species" (i.e., artifacts) in the "artifact structure" of clusters are open to question. Finished artifacts such as retouched flakes, endscrapers, hammerstones, and split pebbles are alluded to in the literature commonly. The defining typological features for these classes are, however, a vague combination of technological, stylistic, and functional elements. Ideally, a study of this type would begin with a systematic formulation of an artifact taxonomy. But this very area of archaeology is also in a state of flux: how and when do we identify inter-assemblage variability based upon tradition and style as opposed to activity and function, and vice versa?

An artifact typology must be chosen with this question in mind. In his description of Yukon Territory artifacts, Morlan (1973:4,42) opts for a Bordian approach in which artifact classes cross-cut functional groups. Whallon (1973a) argues that the spatial analysis of artifacts can provide fundamental confirmation for Binford's "functional" argument. The basic problem (unstratified Boreal Forest sites) and the basic premise (discrete, structured human activity) of this study should draw attention to the significance of both approaches in understanding intra-assemblage variability. Sackett's (1973:320) reference to functional and stylistic modes for each artifact has a great deal of merit in the consideration of an intermediate order archaeological entity, the spatial cluster of artifacts. Spatial clusters simultaneously express functional and stylistic variability also and a thorough understanding of heterogeneity in artifact assemblages from unstratified Boreal Forest sites relies upon both aspects. Unfortunately, I must propose that the material remains of technologies once in use at HkPa 4--primarily lithic artifacts--display a limited functional and stylistic variability that proves to be an effective handicap in archaeological interpretation.

There are significant drawbacks in the research design which I have proposed. First among these is the question of applicability. Although a general strategy involving the horizontal segmentation of artifact distributions seems to be one of the very few avenues by which Boreal Forest archaeologists can begin to explain the temporal variability in artifact assemblages recovered from thinly stratified sites, the approach suggested here emphasizes conditions unique to HkPa 4. The site is very large, but artifact density is, for the most part, low to moderate. Application at small sites with high artifact density would likely be of limited value.

In the same vein, not every Boreal Forest site should be considered to have substantial time depth. Indeed, the extreme paucity of artifacts at many Boreal Forest sites suggests that they are synchronic manifestations of short duration. Since the Boreal Forest has many depositional processes comparable to other areas in which stratified sites are common, the effective absence of stratigraphy may have cultural antecedents. That is, site selection criteria and adaptive strategies may lead to this situation and not the strict lack of geophysical processes. Persistent reliance on a dispersed, mobile animal like the moose could have very real implications for the likelihood of repeated site use. When diverse diagnostic artifacts from a site indicate some temporal depth, however, the assumption of synchroneity does not follow and it is necessary to explore alternative approaches such as the one suggested here in order to make the best use of that data.

There is no apparent solution for the most severe drawbacks in this type of analysis. In some areas of the site, artifact concentrations are more intense (as the result of synchronic or diachronic activity), and in these situations, spatial artifact clusters are not discrete. They overlap. Because there is no stratigraphy which can be used effectively, these areas are best rejected from analysis because of the inherent difficulties in trying to segment the resultant continuum in artifact distribution. At the same time, a margin of error exists in the composition of the spatial clusters which have been defined. Unrecognized overlap and natural disturbance doubtlessly causes fallacious association of some artifacts within clusters. It is equally possible that some items rejected from clusters(say, on the basis of anomalous depth) really did belong with the clusters from which they were removed. Not only does synchroneity remain difficult to prove, but the exact content of a cluster can be variable.

Concluding Remarks

The problem of the stratigraphic compression of chronologically separated artifact assemblages on unstratified Boreal Forest sites is a thorny one. However, advances in our understanding of the temporal variability apparent at the sites of this type cannot be forthcoming when this fundamental difficulty goes unconsidered. While the research design employed suffers from the theoretical weaknesses just cited, it is at least an effort to cope with a perplexing situation.

To validate its use, the basic strategy suggested here could be tested on components known to be synchronic. In situations where similar assumptions can be made about generative processes and the nature of artifact distributions, the procedure of defining clusters does have useful advantages over other approaches. The major drawback would continue to be cluster overlap: a suitable distribution must be typified by spatially discrete aggregates. This experimentation would provide the opportunity to explore variability in the material remains from a site while holding the temporal dimension constant. The obverse of that strategy, studies aimed at discovering regularities in the utilization of areas of a site through time, has been explored here. The stratified random sampling design suggested in Chapter V would no doubt be a successful elaboration of these objectives.

However, temporal depth greatly influences the large scale patterning of artifact distributions under conditions of limited stratigraphy. For this important aspect of the archaeological record, ignoring the temporal factor is an error. The spatial patterning of clusters is a cumulative phenomenon. I contend that the capacity of this research design to provide temporal control on unstratified sites remains only partially tested owing to small sample size. This is a procedural difficulty with a clear solution. I also posit that patterning in the distribution of spatial clusters will almost certainly be detected with the application of larger sampling units. If temporal controls over this patterning can be effected, a more precise idea of the archaeological manifestations of social and economic organization at specific points in time becomes possible.

Although solutions to these problems may not be completely effective, their resolution would permit progress in two directions. The temporal dimension of the archaeological record at many Boreal Forest sites, particularly data basic to processes of cultural change and culture history, will become available for interpretation. More importantly, the approach suggested here retains the potential for a more refined understanding of the processes responsible for the formation of the archaeological record.

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APPENDIX A

ARTIFACT DISTRIBUTIONS

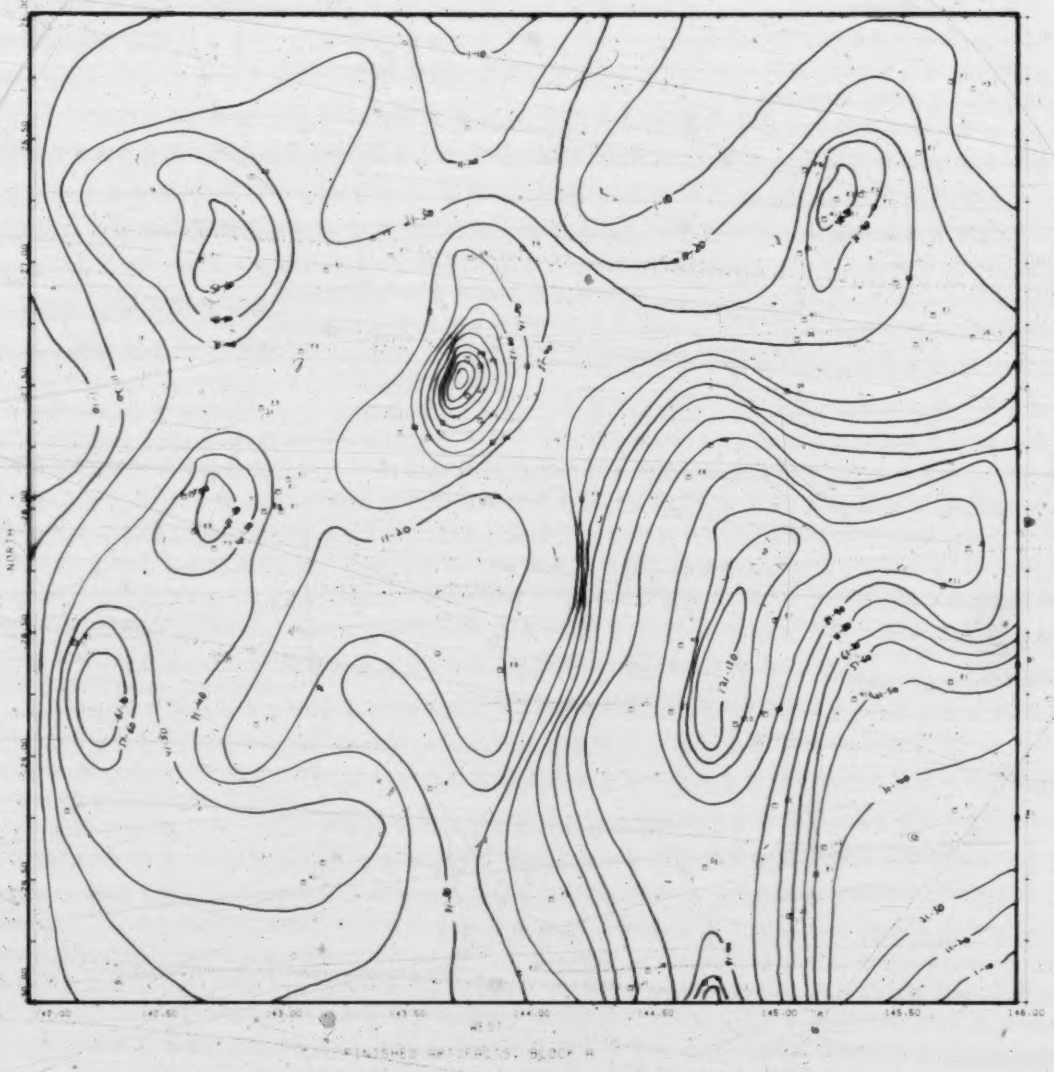
NORTH
142.00
142.50
143.00
143.50
144.00
144.50
145.00
145.50
146.00
EAST
FINISHED ARTIFACTS, BLOCK A

Figure 6. Distribution of finished artifacts in Block A, HkPa 4. Transparency shows density isonomes and indicates concentrations of debitage. The distribution of finished artifacts shows significant departures from randomness only at higher order neighbours; the size of this sampling unit is small. Two denser clumps in the North central area were accepted as spatial clusters.

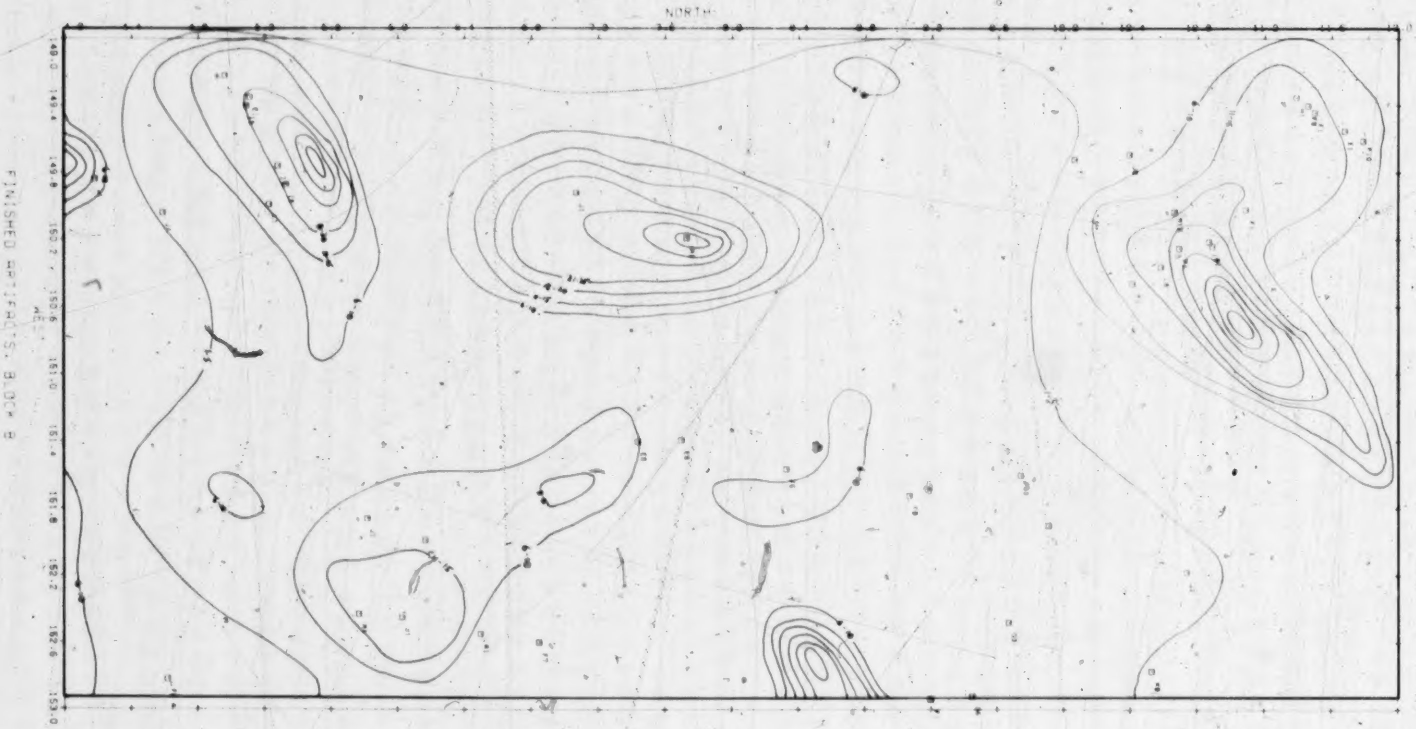
NORTH
149.0
149.4
149.8
150.2
150.6
151.0
151.4
151.8
152.2
152.6
153.0
WEST
FINISHED ARTIFACTS, BLOCK B

Figure 7. Distribution of finished artifacts in Block B, HkPa 4. Transparency shows density isonomes and indicates concentrations of debitage. The distribution of finished artifacts shows moderate intensity, and the aggregates defined tend to regular spacing.

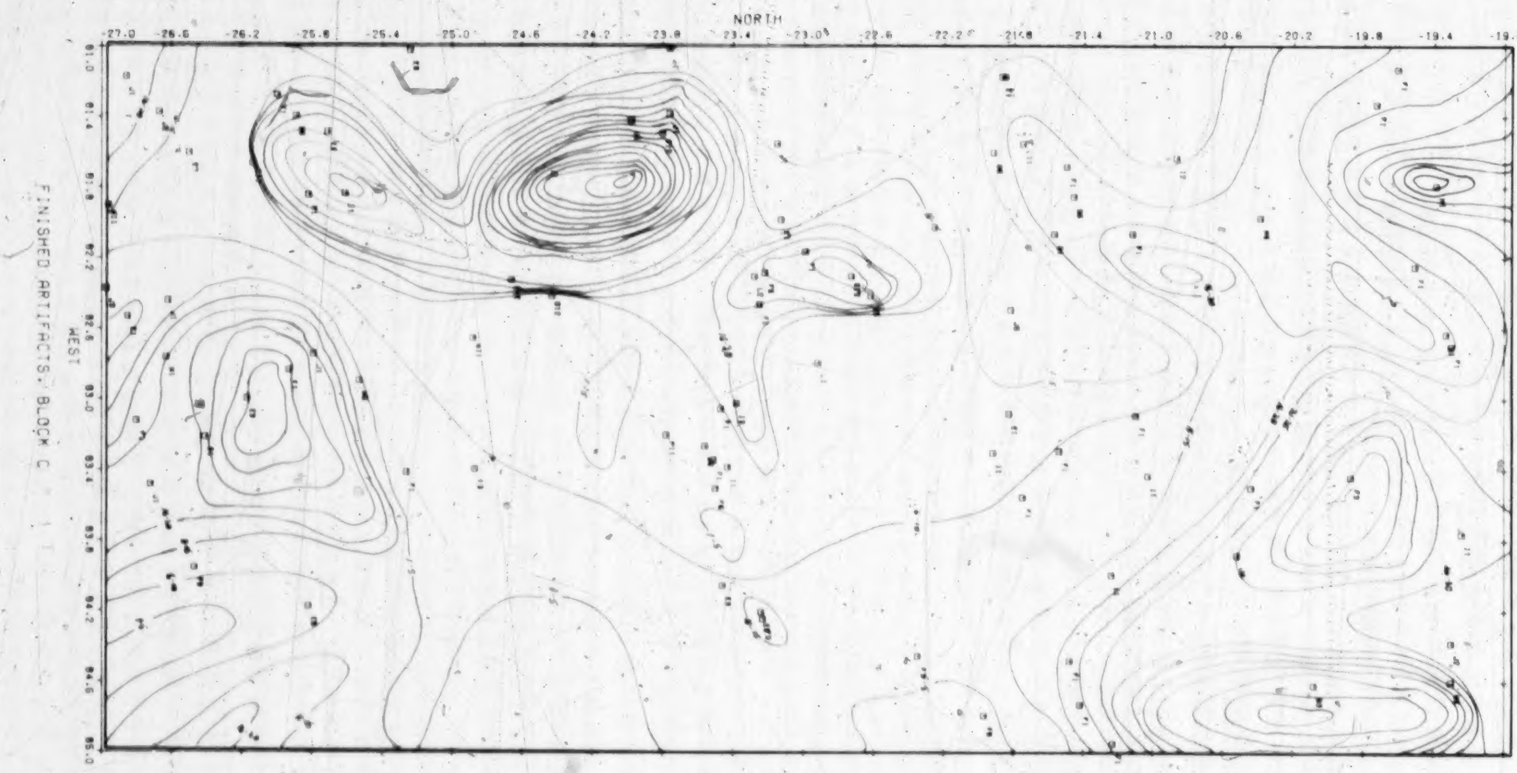
NORTH
-27.0
-26.6
-26.2
-25.8
-25.4
-25.0
-24.6
-24.2
-23.8
-23.4
-23.0
-22.6
-22.2
-21.8
-21.4
-21.0
-20.6
-20.2
-19.8
-19.4
-19.0
WEST
81.0
81.4
81.8
82.2
82.6
83.0
83.4
83.8
84.2
84.6
85.0
FINISHED ARTIFACTS, BLOCK C

Figure 8. Distribution of finished artifacts in Block C, HkPa 4. Transparency shows density isonomes and indicates concentrations of debitage. The East half of the finished artifact distribution does not depart from randomness significantly, while the West half shows moderate intensity in patterning.

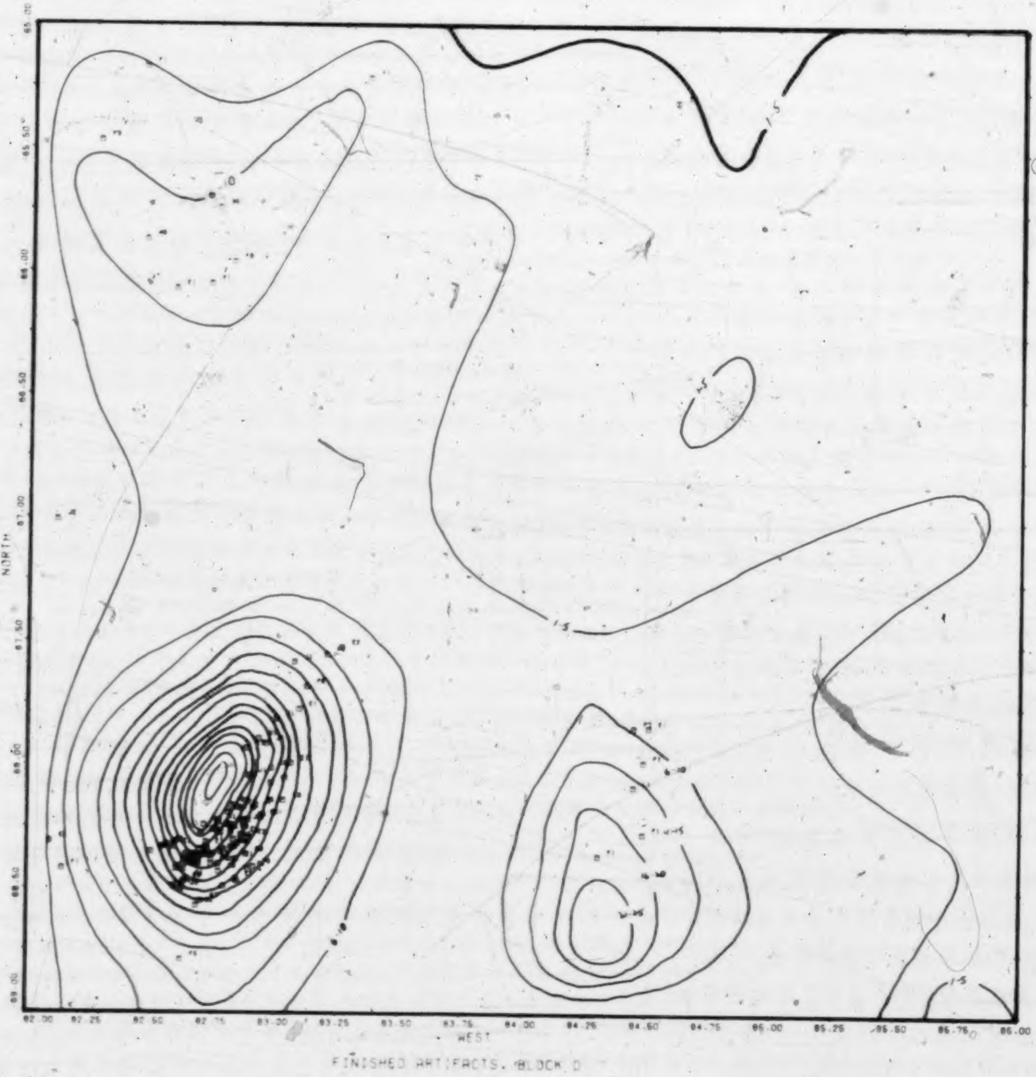

Figure 9. Distribution of finished artifacts in Block D, HkPa 4. Transparency shows density isonomes and indicates concentrations of debitage. Note the high density area (D2) in the northwest corner of the unit. Patterning is highly intense.

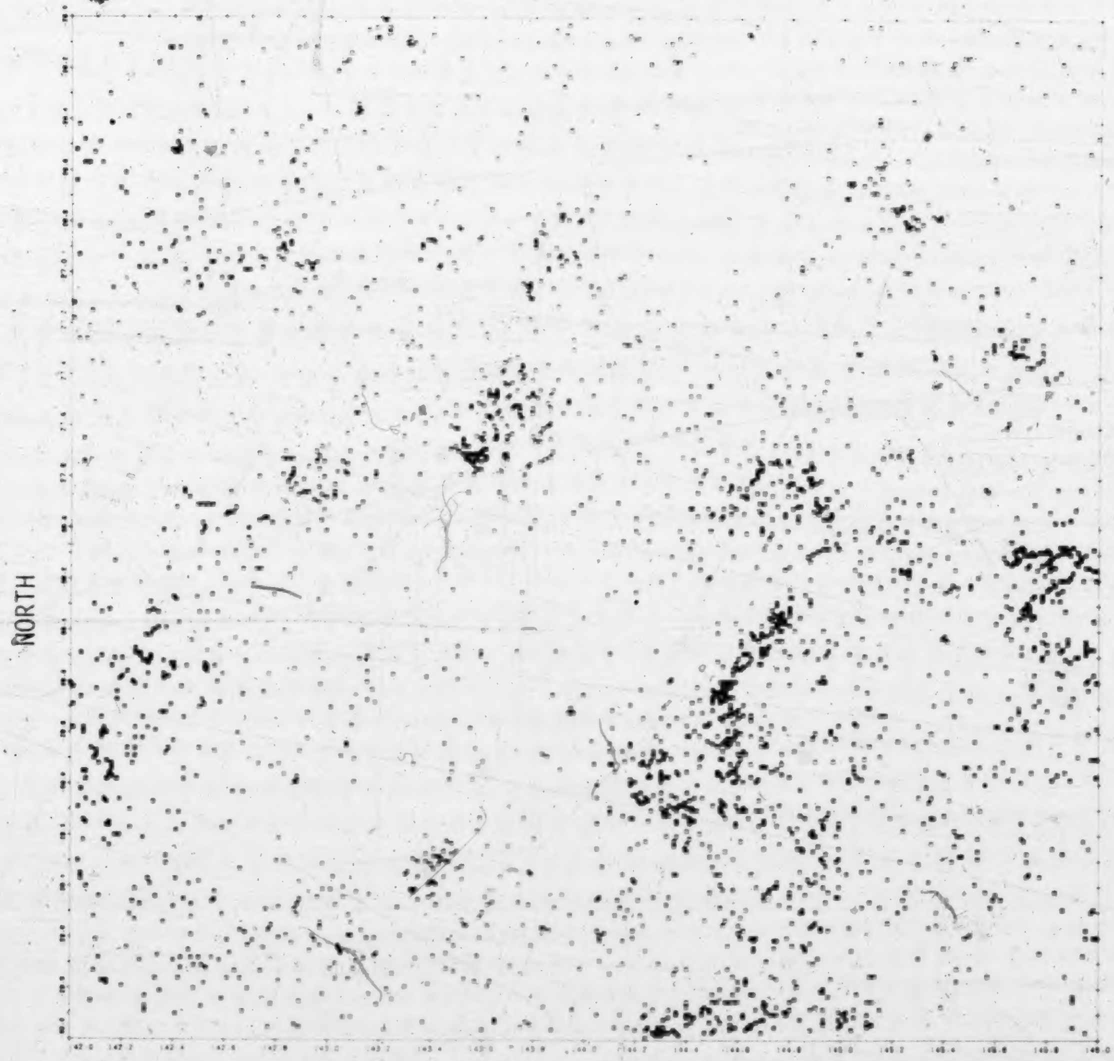

Figure 10. Distribution of all classes of artifacts in Block A, HkPa 4. 2609 artifacts were recovered from this high density area. Cluster overlap is a problem in this unit.

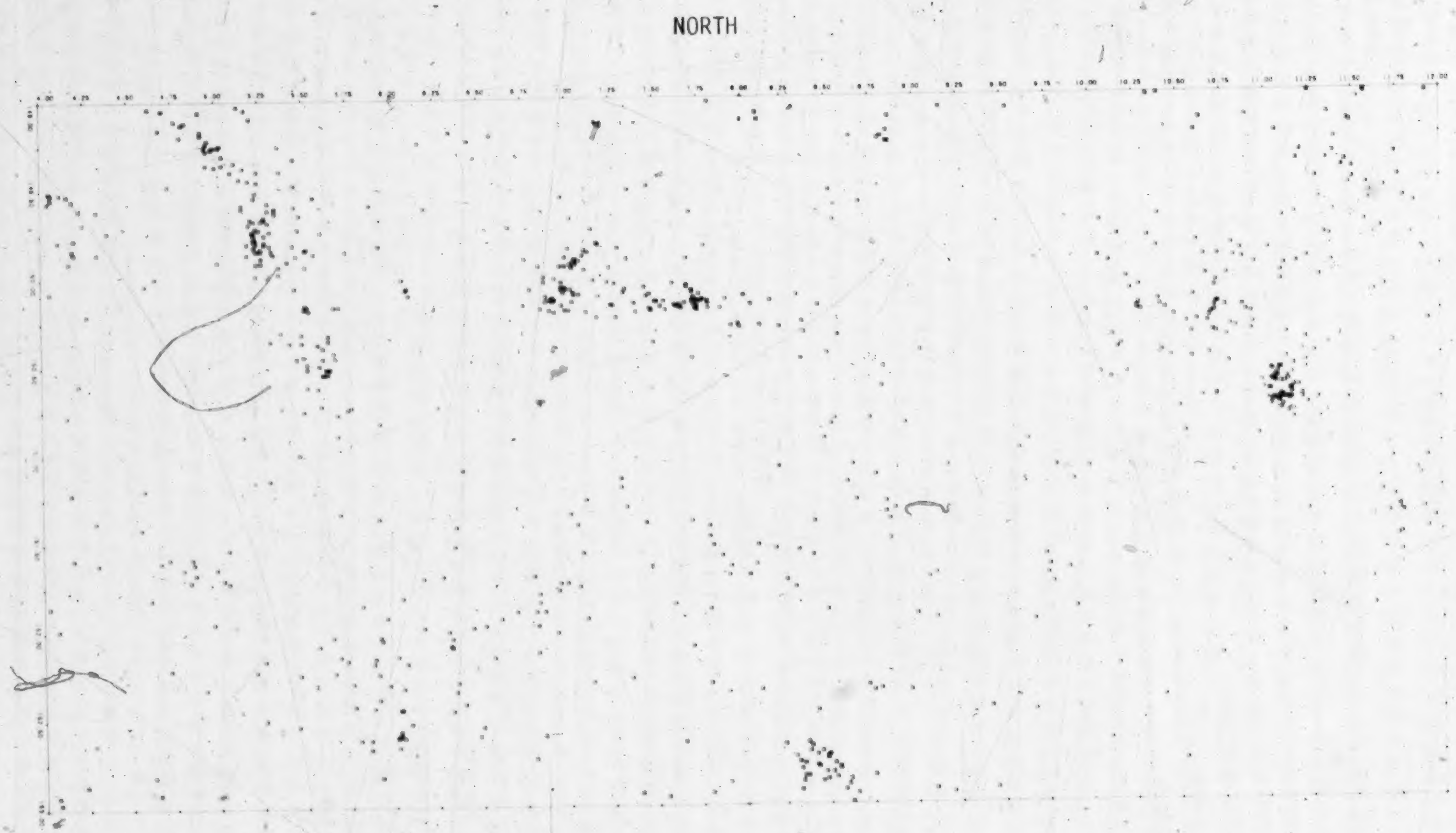
NORTH
4.00
4.25
4.50
4.75
5.00
5.25
5.50
5.75
6.00
6.25
6.50
6.75
7.00
7.25
7.50
7.75
8.00
8.25
8.50
8.75
9.00
9.25
9.50
9.75
10.00
10.25
10.50
10.75
11.00
11.25
11.50
11.75
12.00

Figure 11. Distribution of all classes of artifacts in Block B, HkPa 4. 756 artifacts were recovered from this moderate density area. Concentrations of debitage tend to be quite discrete.

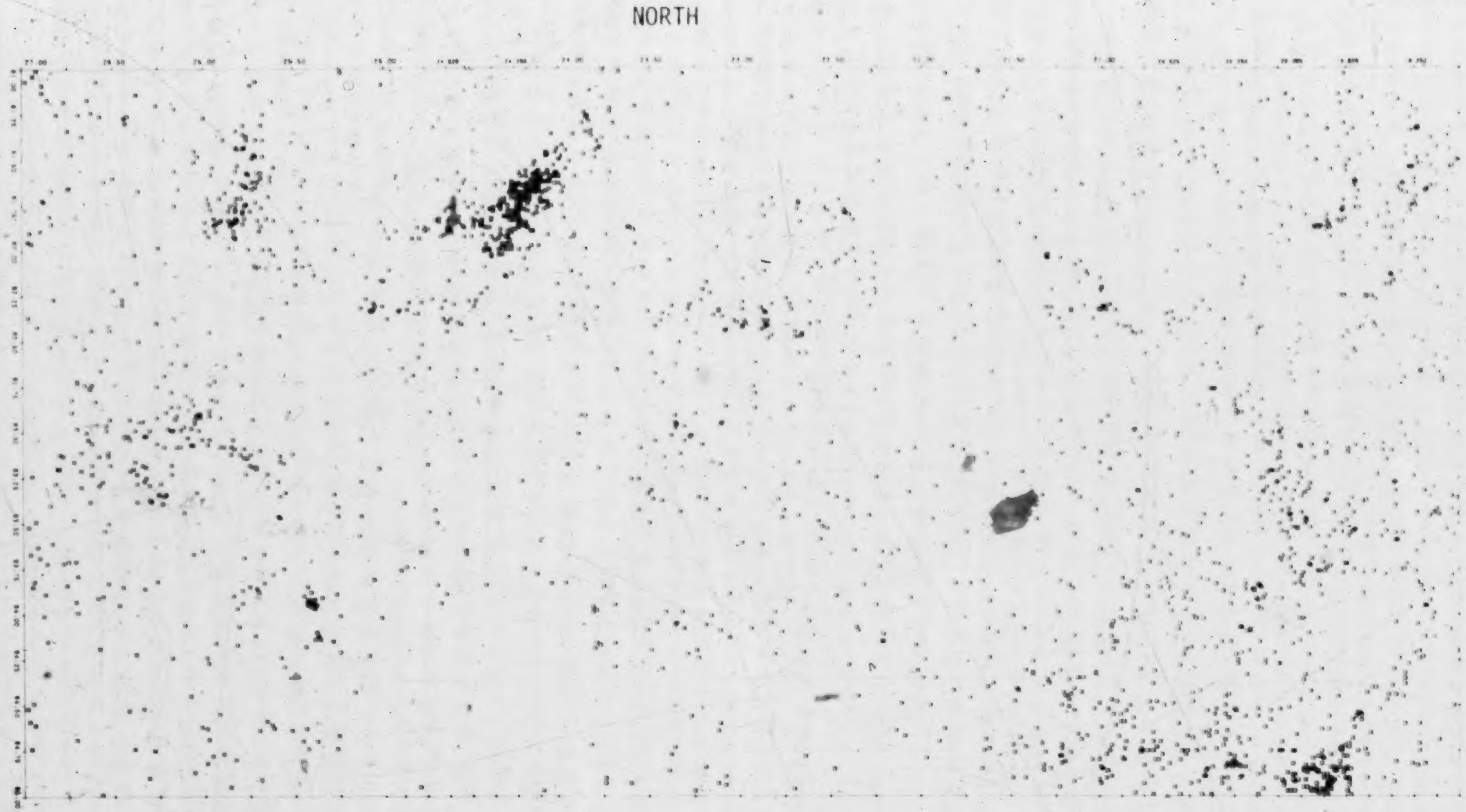

Figure 12. Distribution of all classes of artifacts in Block C, HkPa 4. 2112 artifacts were recovered from this high density area.

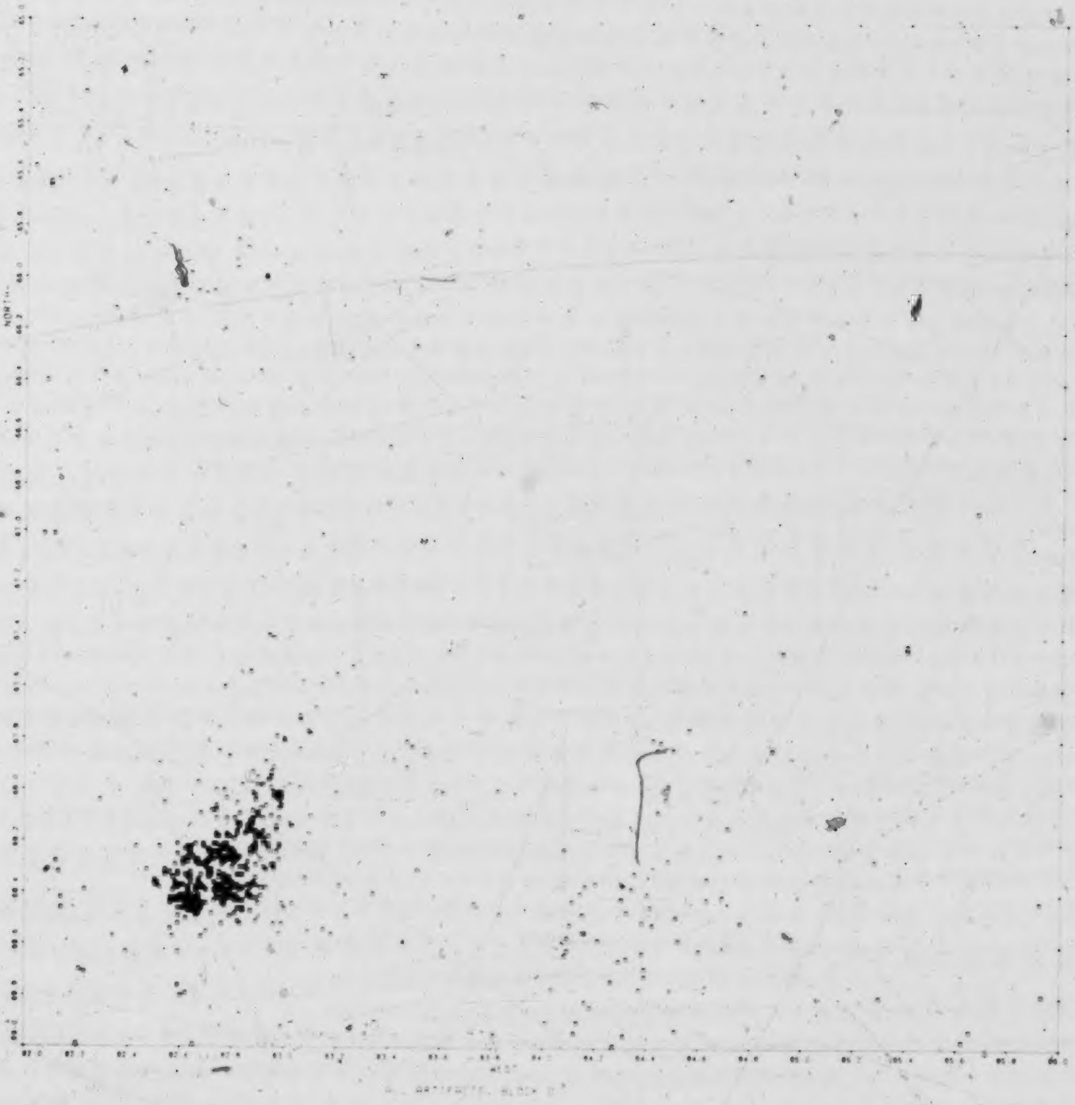

Figure 13. Distribution of all classes of artifacts in Block D, HkPa 4. 535 artifacts were recovered from this low density area. As evidenced by Transect II, which ran through this area, overall artifact density is extremely low and the high density area in the northwest corner is anomalous.

APPENDIX B

MEAN SQUARE BLOCK ANALYSIS GRAPHS

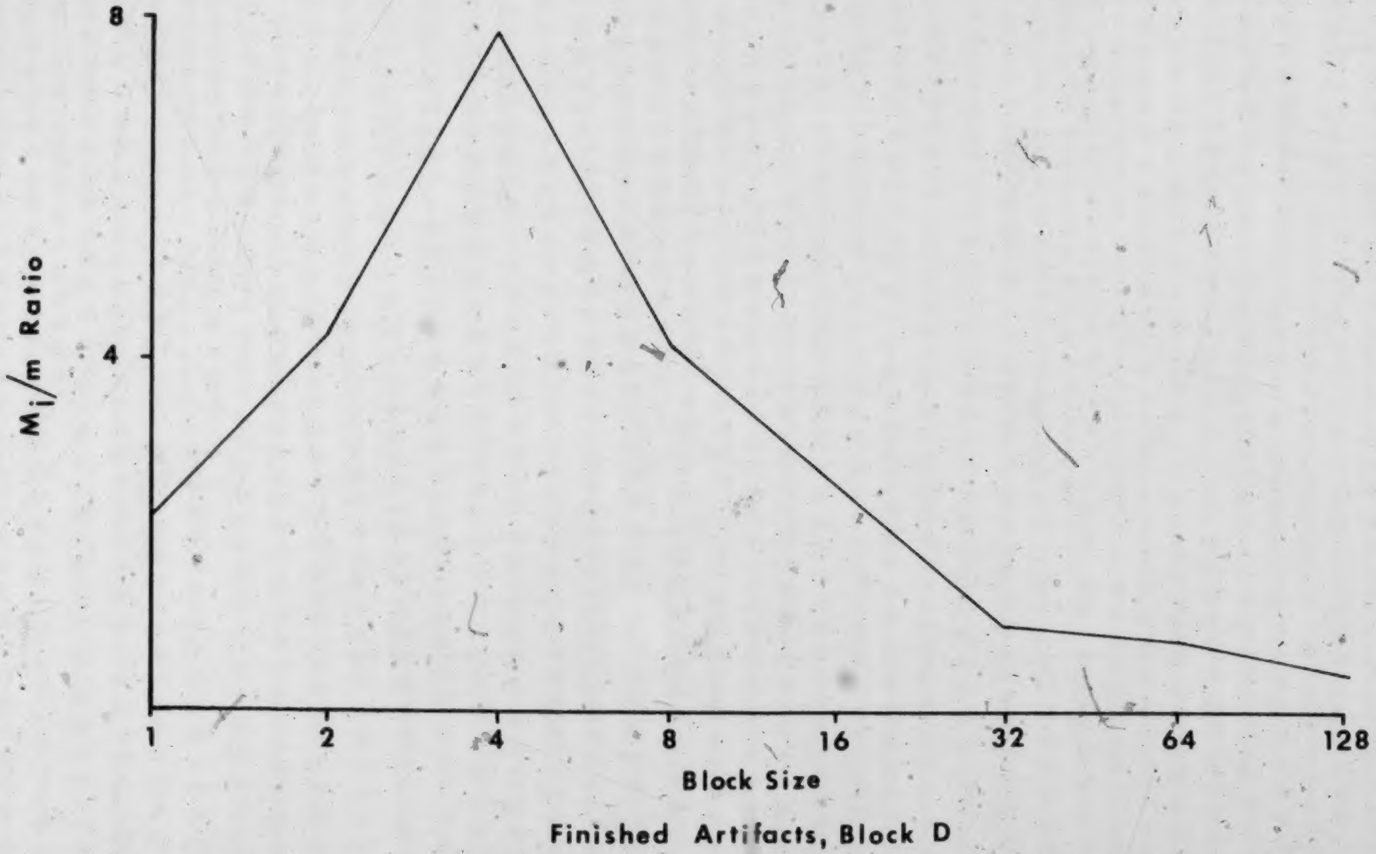

Figure 14. Graph of mean square/mean ratio against block size for finished artifacts in Block D. Initial block size was 0.25 by 0.25 meters. The peak occurs at the 0.50 by 0.50 meter block size.

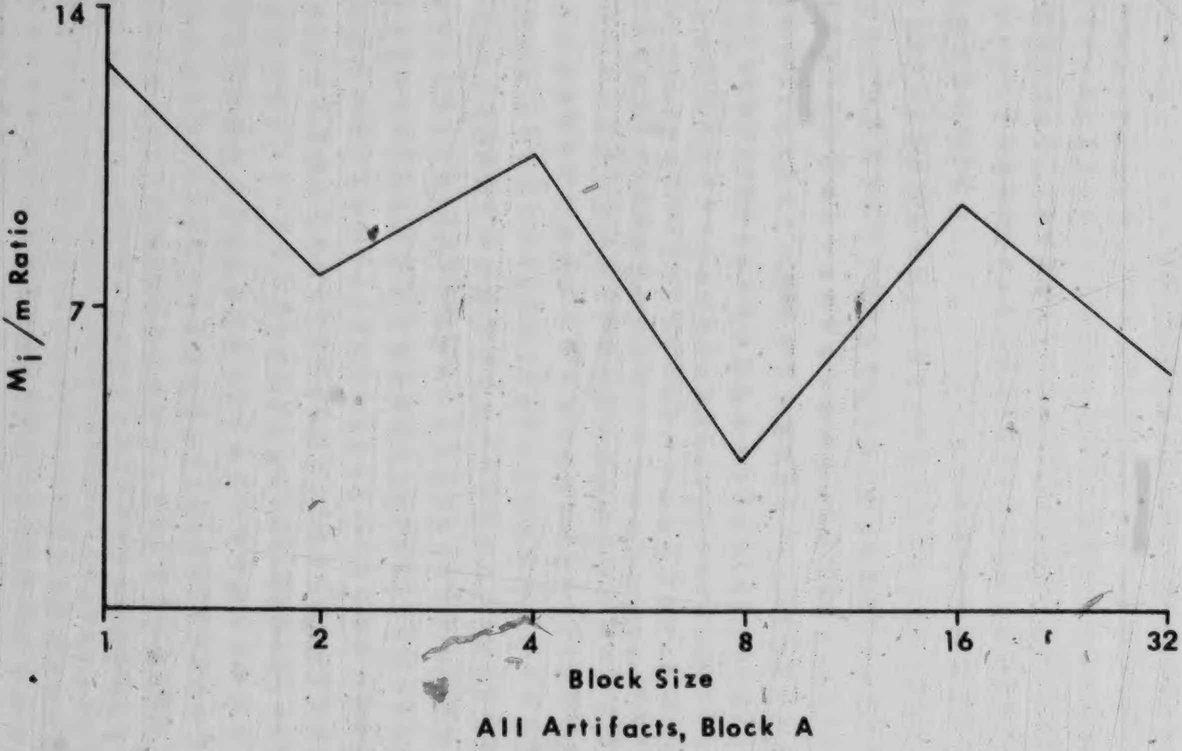

Figure 15. Graph of mean square/mean ratio against block size for all artifacts in Block A. Initial block size was 0.50 by 0.50 meters. The "saw-toothed" effect may stem from the different sampling efficiencies of square (peaks) and rectangular (lows) block shapes.

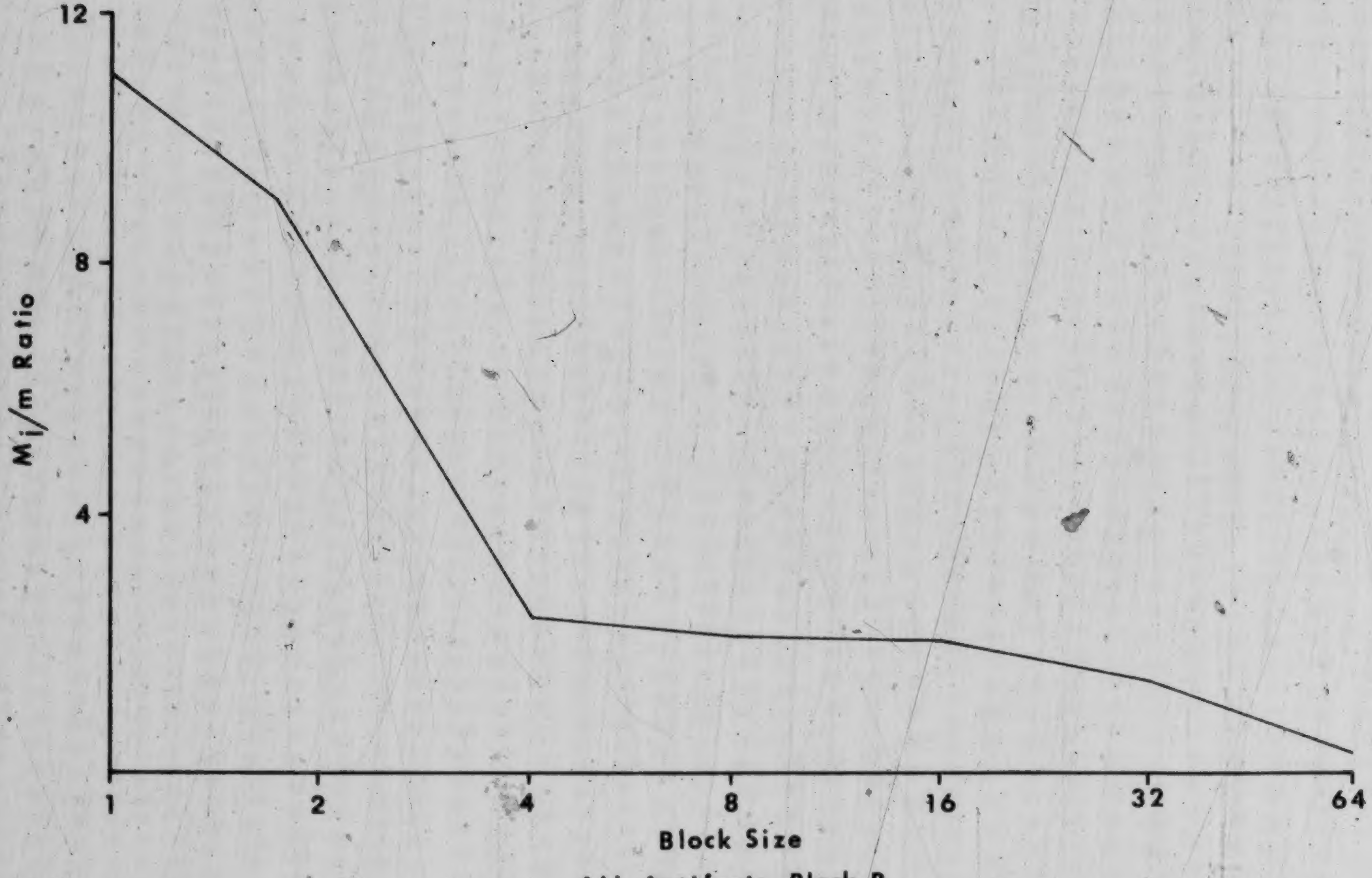

Figure 16. Graph of mean square/mean ratio against block size for all artifacts in Block B. Initial block size was 0.50 by 0.50 meters.

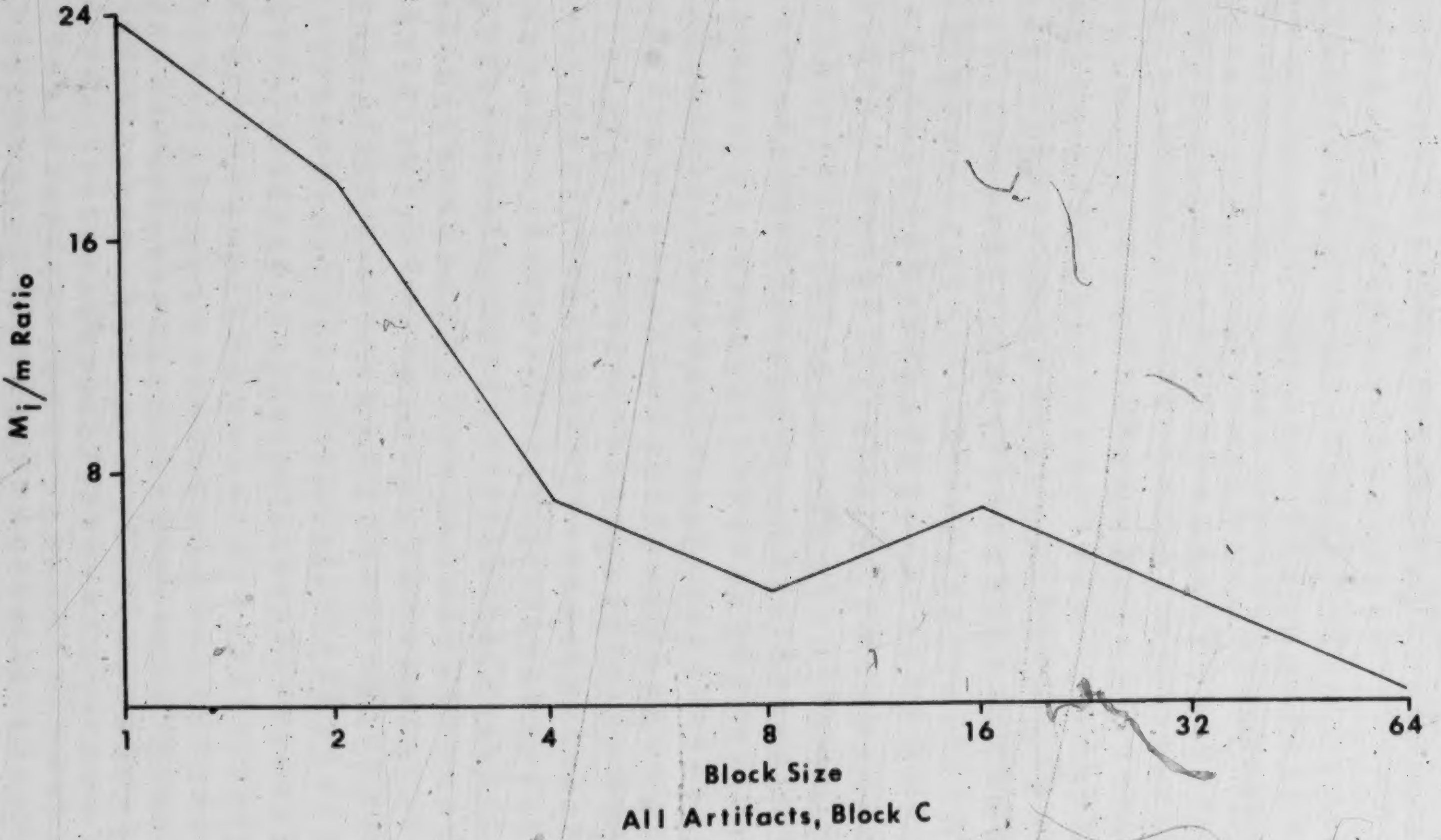

Figure 17. Graph of mean square/mean ratio against block size for all artifacts, Block C. Initial block size was 0.50 by 0.50 meters. The second and smaller peak occurs at the 2.0 by 2.0 meter block size.

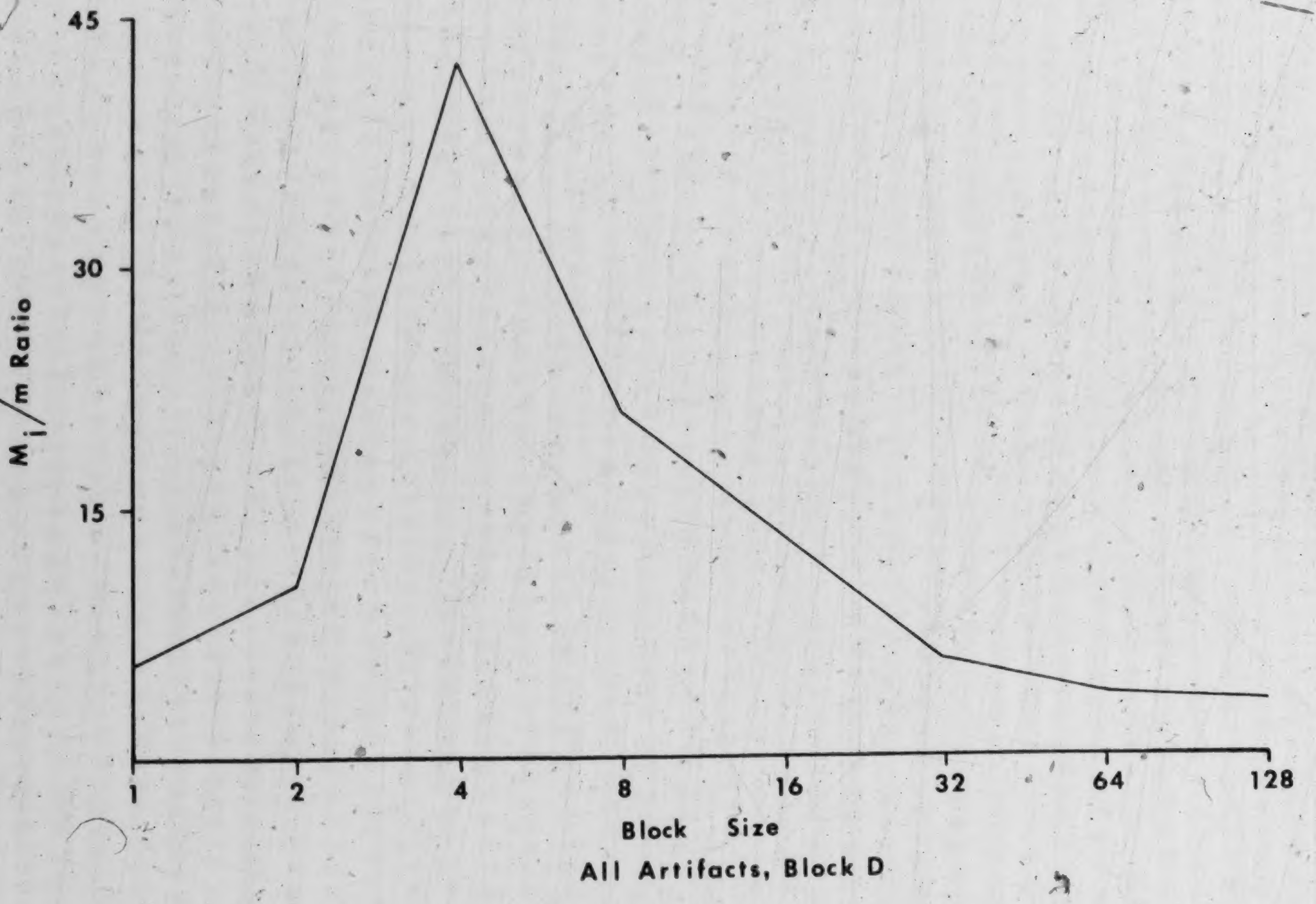

Figure 18. Graph of mean square/mean ratio against block size for all artifacts in Block D. Initial block size was 0.25 by 0.25 meters. The peak occurs at the 0.50 by 0.50 meter block size.

APPENDIX C

ORDER NEIGHBOUR STATISTICS OUTPUT,
BLOCK B, RANDOM BORDER METHOD

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NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

FIRST   NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY      EXPECTED MEAN NEAREST
     OBSERVATIONS                          NEIGHBOUR DISTANCE

       42        32.0000      1.3125             0.4364

     MEAN NEAREST           R        STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                       VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                    OF A RANDOM DISTRIBUTION

       0.2920           0.6690      -4.103        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                     FREEDOM

        42.574        84.                -3.695

NORMAL APPROXIMATION            5% CONFIDENCE          WILSON-HILPERTY
 (CHI-SQUARE/N)                   LIMITS               APPROXIMATION
    1.0137                      1.4308                  1.4413
                                2.6369                  2.6487


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      0.6122

NUMBER OF POINTS REJECTED    38

CRITICAL BOUNDARY     1.0000 METERS
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```
NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

SECOND  NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY     EXPECTED MEAN NEAREST
     OBSERVATIONS                         NEIGHBOUR DISTANCE

       42        32.0000      1.3125            0.6547

     MEAN NEAREST         R         STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                      VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                   OF A RANDOM DISTRIBUTION

        0.4952          0.7564      -4.531        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE     DEGREES OF    STANDARD VARIATE
                    FREEDOM

        114.378       168.              -3.178

NORMAL APPROXIMATION          5% CONFIDENCE           WILSON-HILFERTY
 (CHI-SQUARE/N)                 LIMITS                APPROXIMATION
   2.7233                     3.1797                   3.1904
                              4.8880                   4.8996


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      0.9763

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
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NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

THIRD NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY     EXPECTED MEAN NEAREST
     OBSERVATIONS                         NEIGHBOUR DISTANCE

      42         32.0000      1.3125            0.8183

     MEAN NEAREST           R          STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                         VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                      OF A RANDOM DISTRIBUTION

        0.6653          0.8130         -4.346       0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                     FREEDOM

        188.281       252.              -3.022

NORMAL APPROXIMATION            5% CONFIDENCE           WILSON-HILFERTY
 (CHI-SQUARE/N)                    LIMITS               APPROXIMATION
    4.4829                     4.9872                    4.9981
                               7.0804                    7.0921


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      1.1895

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
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NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

FOURTH  NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

          NUMBER OF      AREA      DENSITY      EXPECTED MEAN NEAREST
          OBSERVATIONS                          NEIGHBOUR DISTANCE

            42        32.0000      1.3125           0.9547

          MEAN NEAREST          R        STANDARD    STANDARD ERROR OF MEAN
          NEIGHBOUR                      VARIATE     NEAREST NEIGHBOUR DISTANCE
          DISTANCE                                   OF A RANDOM DISTRIBUTION

            0.7697         0.8062        -5.256        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

          CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                          FREEDOM

            250.133       336.            -3.537

NORMAL APPROXIMATION               5% CONFIDENCE               WILSON-HILFERTY
 (CHI-SQUARE/N)                       LIMITS                   APPROXIMATION
    5.9556                         6.8250                       6.8359
                                   9.2427                       9.2542


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      1.3641

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
```

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NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

FIFTH   NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY      EXPECTED MEAN NEAREST
     OBSERVATIONS                          NEIGHBOUR DISTANCE

       42        32.0000       1.3125            1.0740

     MEAN NEAREST          R        STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                      VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                   OF A RANDOM DISTRIBUTION

        0.8944          0.8327      -5.103        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                     FREEDOM

       318.161        420.               -3.740

NORMAL APPROXIMATION             5% CONFIDENCE           WILSON-HILFERTY
 (CHI-SQUARE/N)                     LIMITS               APPROXIMATION
    7.5753                        8.6821                  8.6931
                                 11.3855                 11.3971


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      1.4627

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
```

```
NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

SIXTH   NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY     EXPECTED MEAN NEAREST
     OBSERVATIONS                         NEIGHBOUR DISTANCE

       42        32.0000       1.3125            1.1814

     MEAN NEAREST          R          STANDARD   STANDARD ERROR OF MEAN
     NEIGHBOUR                        VARIATE    NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                    OF A RANDOM DISTRIBUTION

        1.0126          0.8571       -4.795        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE     DEGREES OF    STANDARD VARIATE
                    FREEDOM

        392.540       504.            -3.714

NORMAL APPROXIMATION              5% CONFIDENCE            WILSON-HILFERTY
 (CHI-SQUARE/N)                      LIMITS                APPROXIMATION
    9.3462                        10.5529                  10.5639
                                  13.5147                  13.5262

THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      1.5546

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
```

```
NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

SEVENTH NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

      NUMBER OF       AREA      DENSITY      EXPECTED MEAN NEAREST
      OBSERVATIONS                           NEIGHBOUR DISTANCE

         42         32.0000      1.3125           1.2799

      MEAN NEAREST           R          STANDARD   STANDARD ERROR OF MEAN
      NEIGHBOUR                         VARIATE    NEAREST NEIGHBOUR DISTANCE
      DISTANCE                                     OF A RANDOM DISTRIBUTION

         1.1192          0.8745       -4.564        0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

      CHI-SQUARE       DEGREES OF     STANDARD VARIATE
                       FREEDOM

         468.216        588.             -3.677

NORMAL APPROXIMATION           5% CONFIDENCE          WILSON-HILFERTY
 (CHI-SQUARE/N)                   LIMITS              APPROXIMATION
   11.1480                      12.4342               12.4452
                                15.6335               15.6449


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

5% NORMAL CURVE CUTOFF POINT =      1.6387

NUMBER OF POINTS REJECTED    38

CRITICAL BOUNDARY     1.0000 METERS
```

```
NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

EIGHTH  NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY      EXPECTED MEAN NEAREST
     OBSERVATIONS                          NEIGHBOUR DISTANCE

       42        32.0000       1.3125          1.3713

     MEAN NEAREST          R        STANDARD     STANDARD ERROR OF MEAN
     NEIGHBOUR                      VARIATE      NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                    OF A RANDOM DISTRIBUTION

       1.2404          0.9045       -3.718        0.035

 NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

      CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                      FREEDOM

        569.261        672.              -2.905

 NORMAL APPROXIMATION           5% CONFIDENCE          WILSON-HILFERTY
  (CHI-SQUARE/N)                   LIMITS              APPROXIMATION
    13.5538                     14.3236                14.3347
                                17.7440                17.7554


 THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
 AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

 SIGNIFICANCE FOUND IN THE DIRECTION OF AGGREGATION

 5% NORMAL CURVE CUTOFF POINT =      1.7748

 NUMBER OF POINTS REJECTED    38

 CRITICAL BOUNDARY     1.0000 METERS
```

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NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

NINTH   NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY      EXPECTED MEAN NEAREST
     OBSERVATIONS                          NEIGHBOUR DISTANCE

       42        32.0000      1.3125           1.4570

     MEAN NEAREST           R        STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                       VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                    OF A RANDOM DISTRIBUTION

        1.4173         0.9727       -1.128       0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                     FREEDOM

       727.592        756.              -0.725

NORMAL APPROXIMATION          5% CONFIDENCE            WILSON-HILFERTY
 (CHI-SQUARE/N)                 LIMITS                 APPROXIMATION
   17.3236                   16.2198                   16.2309
                             19.8478                   19.8592


THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

NO SIGNIFICANCE OF PATTERN FOUND

5% NORMAL CURVE CUTOFF POINT =      1.9175

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
```

```
NEAREST NEIGHBOUR ANALYSIS, RANDOM BORDER, BLOCK B.

TENTH   NEAREST NEIGHBOUR STATISTICS

NEAREST-NEIGHBOUR STATISTICS OF CLARK AND EVANS (1954)

     NUMBER OF      AREA      DENSITY    EXPECTED MEAN NEAREST
     OBSERVATIONS                        NEIGHBOUR DISTANCE

       42         32.0000      1.3125          1.5380

     MEAN NEAREST          R        STANDARD    STANDARD ERROR OF MEAN
     NEIGHBOUR                      VARIATE     NEAREST NEIGHBOUR DISTANCE
     DISTANCE                                   OF A RANDOM DISTRIBUTION

        1.4836          0.9647       -1.544      0.035

NEAREST NEIGHBOUR STATISTICS PRESENTED BY WHALLON (1974) AND OTHERS

     CHI-SQUARE      DEGREES OF    STANDARD VARIATE
                     FREEDOM

       796.988         840.             -1.051

NORMAL APPROXIMATION            5% CONFIDENCE          WILSON-HILFERTY
  (CHI-SQUARE/N)                    LIMITS              APPROXIMATION
   18.9759                      18.1216                 18.1327
                                21.9460                 21.9574

THE CHI-SQUARE STANDARD DEVIATE USED TO TEST FOR SIGNIFICANCE
AT THE 5% CONFIDENCE LEVEL (-1.96 - 1.96)

NO SIGNIFICANCE OF PATTERN FOUND

5% NORMAL CURVE CUTOFF POINT =      2.0051

NUMBER OF POINTS REJECTED   38

CRITICAL BOUNDARY    1.0000 METERS
```

APPENDIX D

CLUSTAN SCATTER PLOTS AND SPATIAL CLUSTERS OUTLINED BY CONVEX HULLS

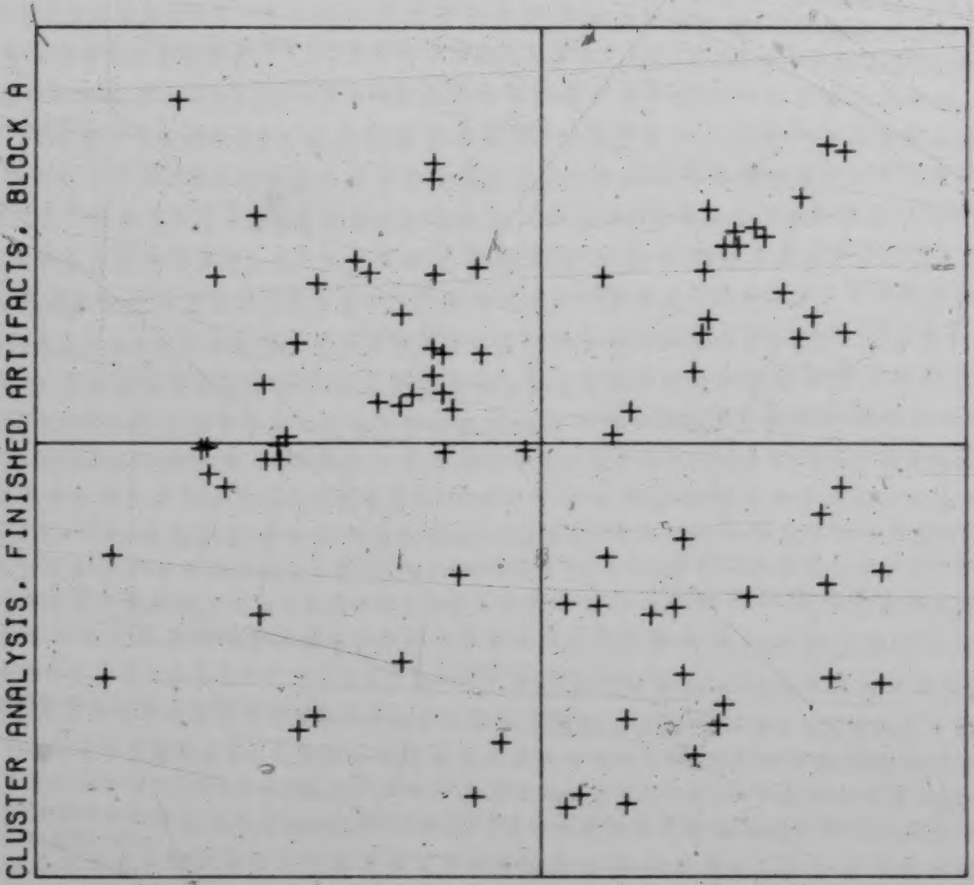

Figure 23. A CLUSTAN scatterplot of the finished artifacts in Block A, HkPa 4.

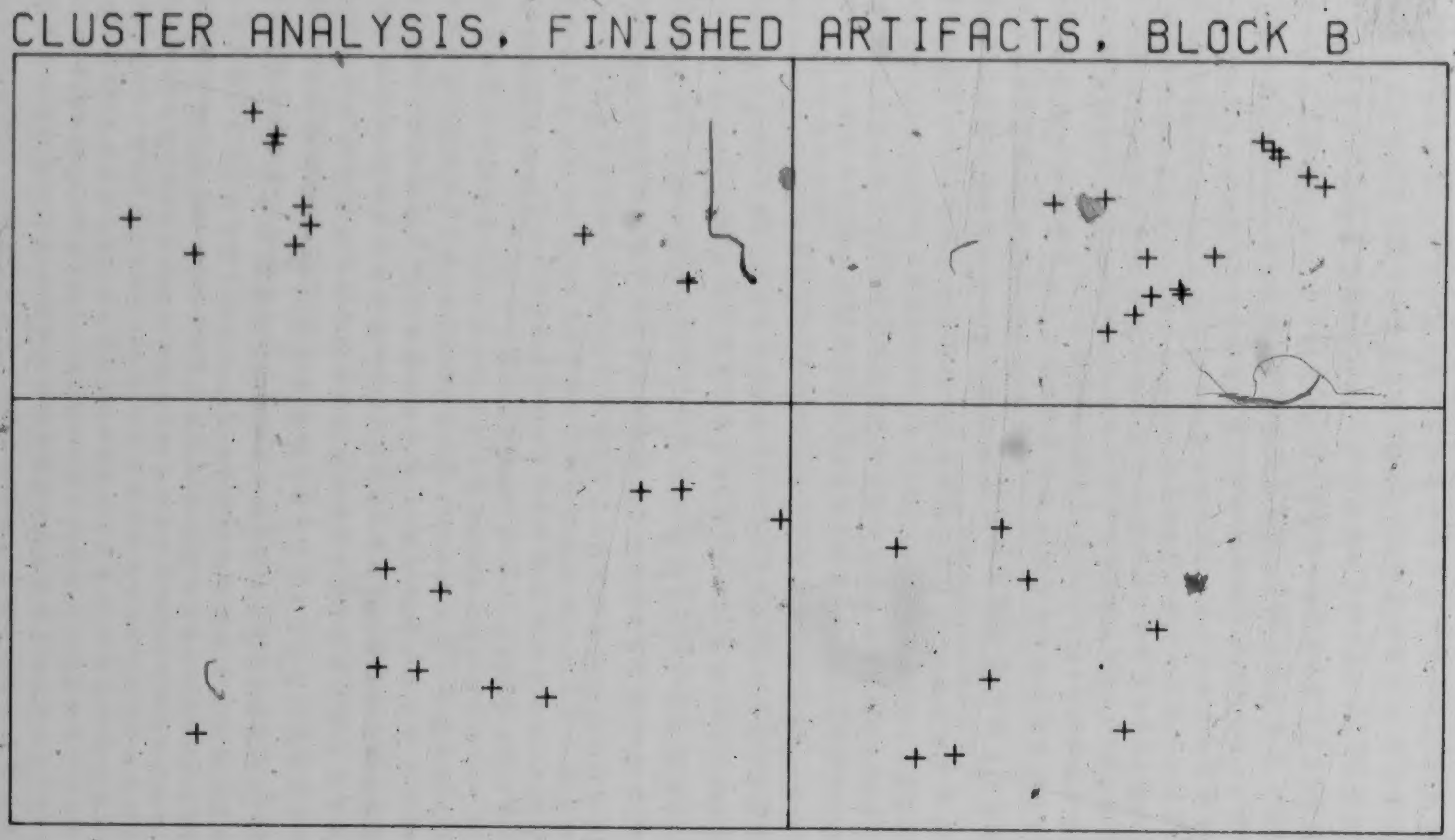

Figure 24. A CLUSTAN scatter plot of the finished artifacts in Block B, HkPa 4.

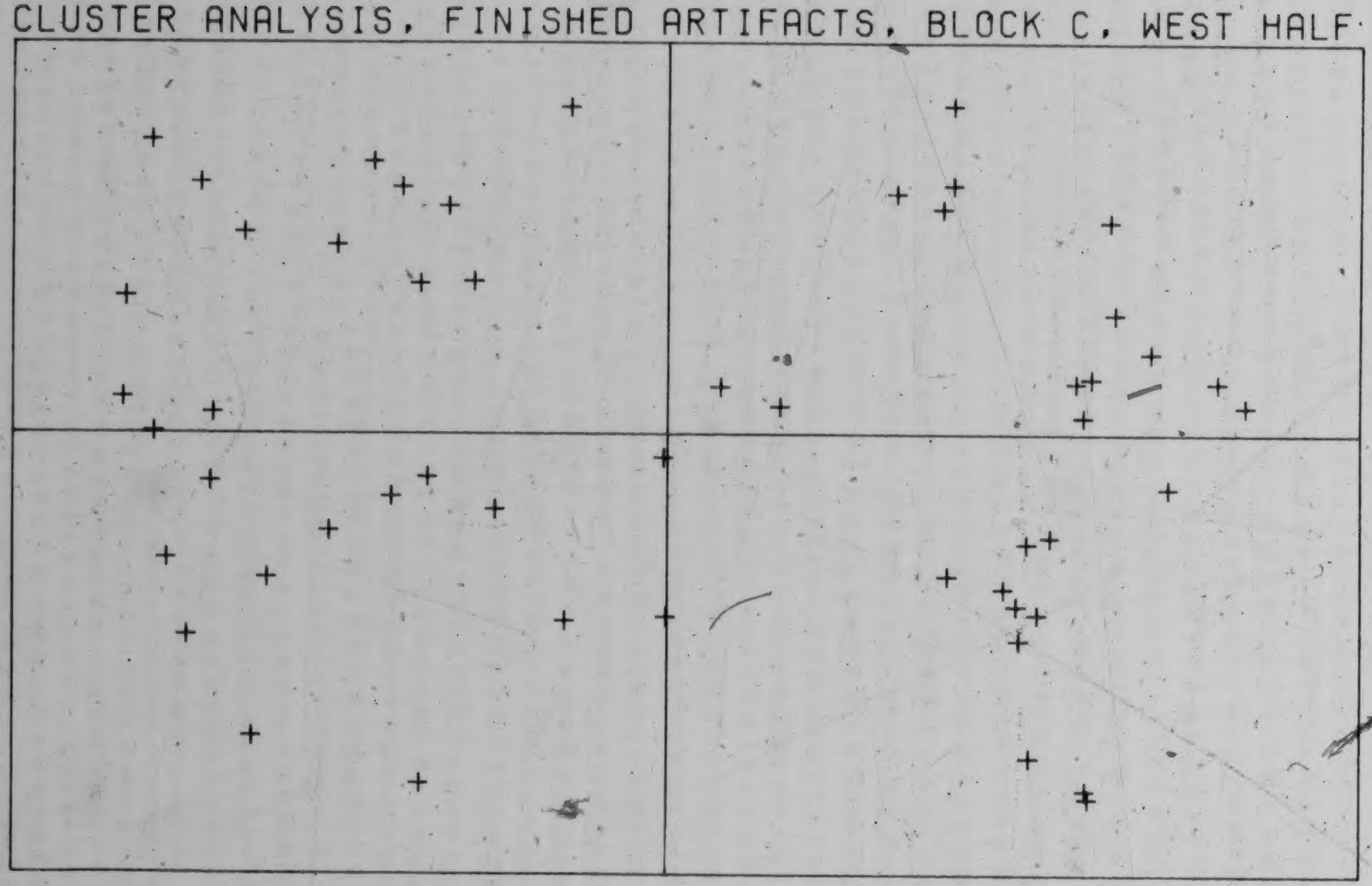

Figure 25. A CLUSTAN scatterplot of the finished artifacts in the West half of Block C, HkPa 4.

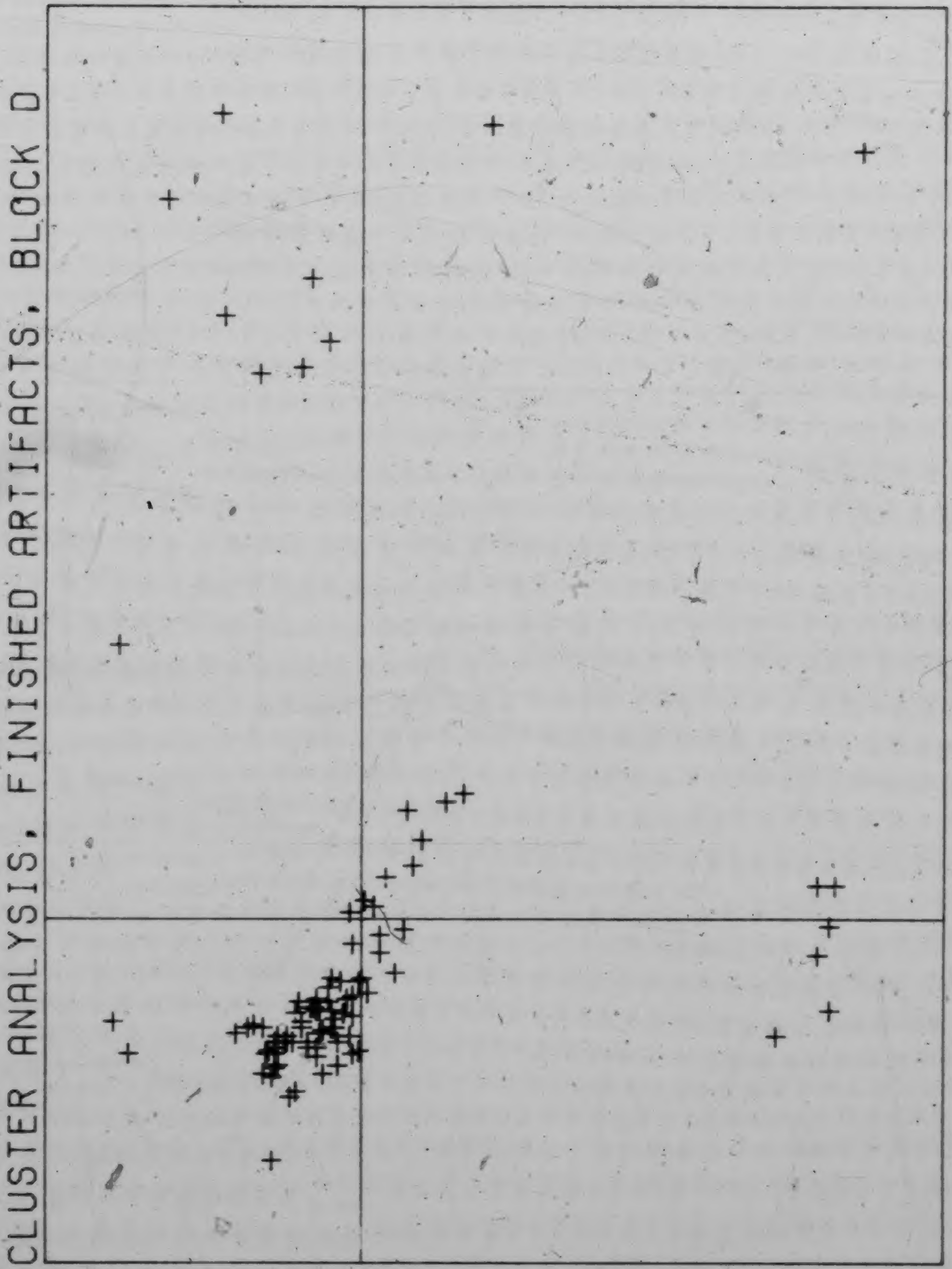

Figure 26. A CLUSTAN scatterplot of the finished artifacts in Block D, HkPa 4.

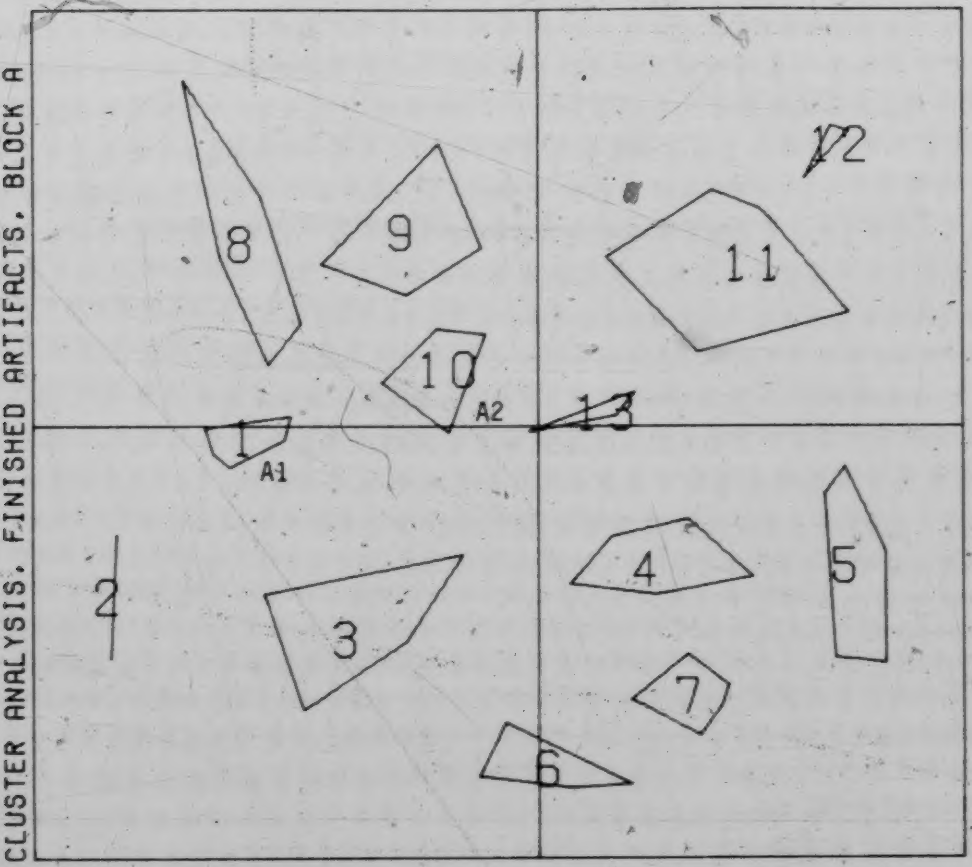

Figure 27. Spatial clusters outlined by convex hulls, Block A, HkPa 4. Block A is not clearly aggregated and only clusters labelled 1 and 10 were accepted.

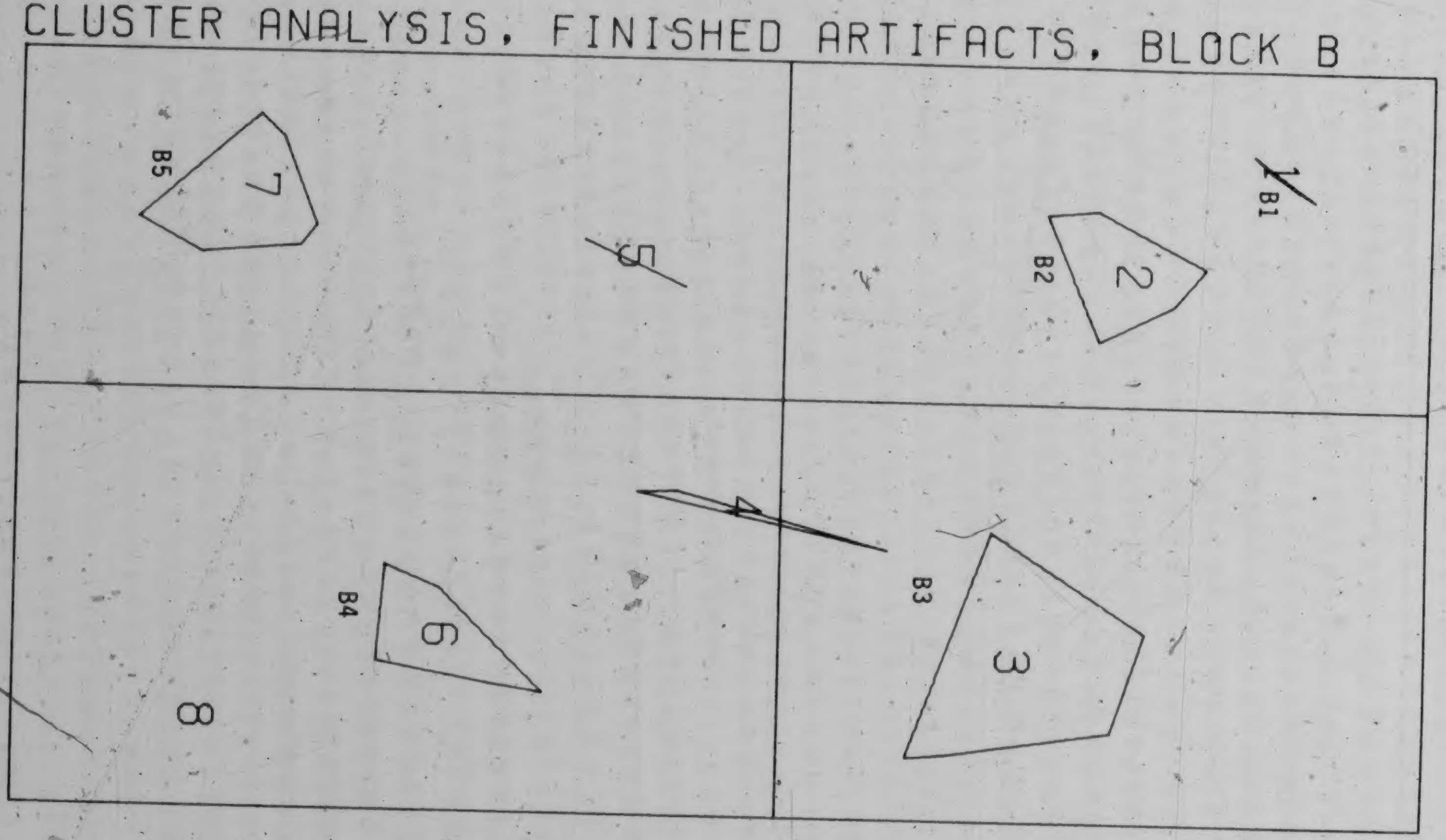

Figure 28. Spatial clusters outlined by convex hulls, Block B, HkPa 4. Only clusters labelled 1, 2, 3, 6, and 7 were accepted.

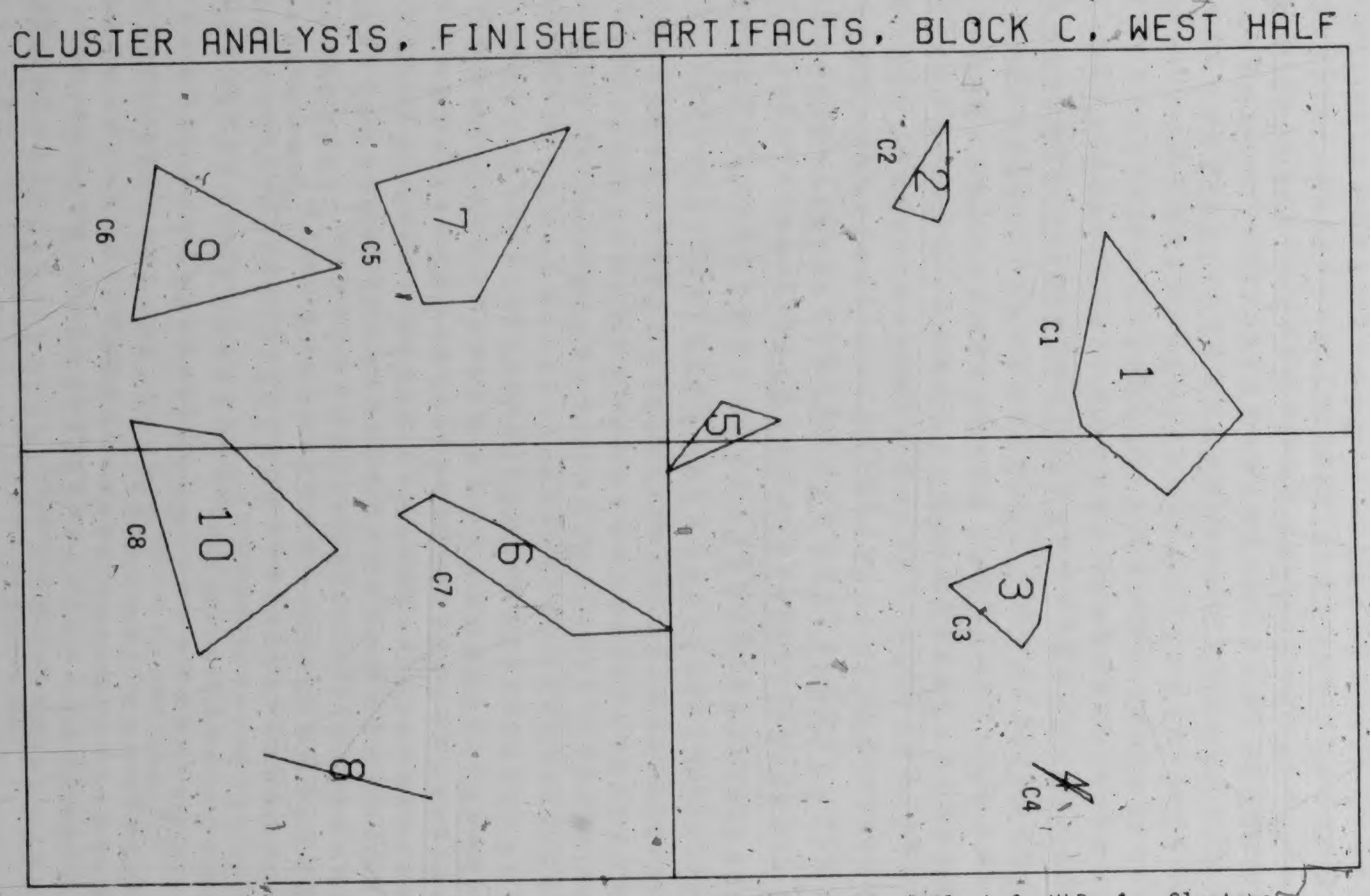

Figure 29. Spatial clusters outlined by convex hulls, West half of Block C, HkPa 4. Clusters labelled 5 and 8 were not accepted.

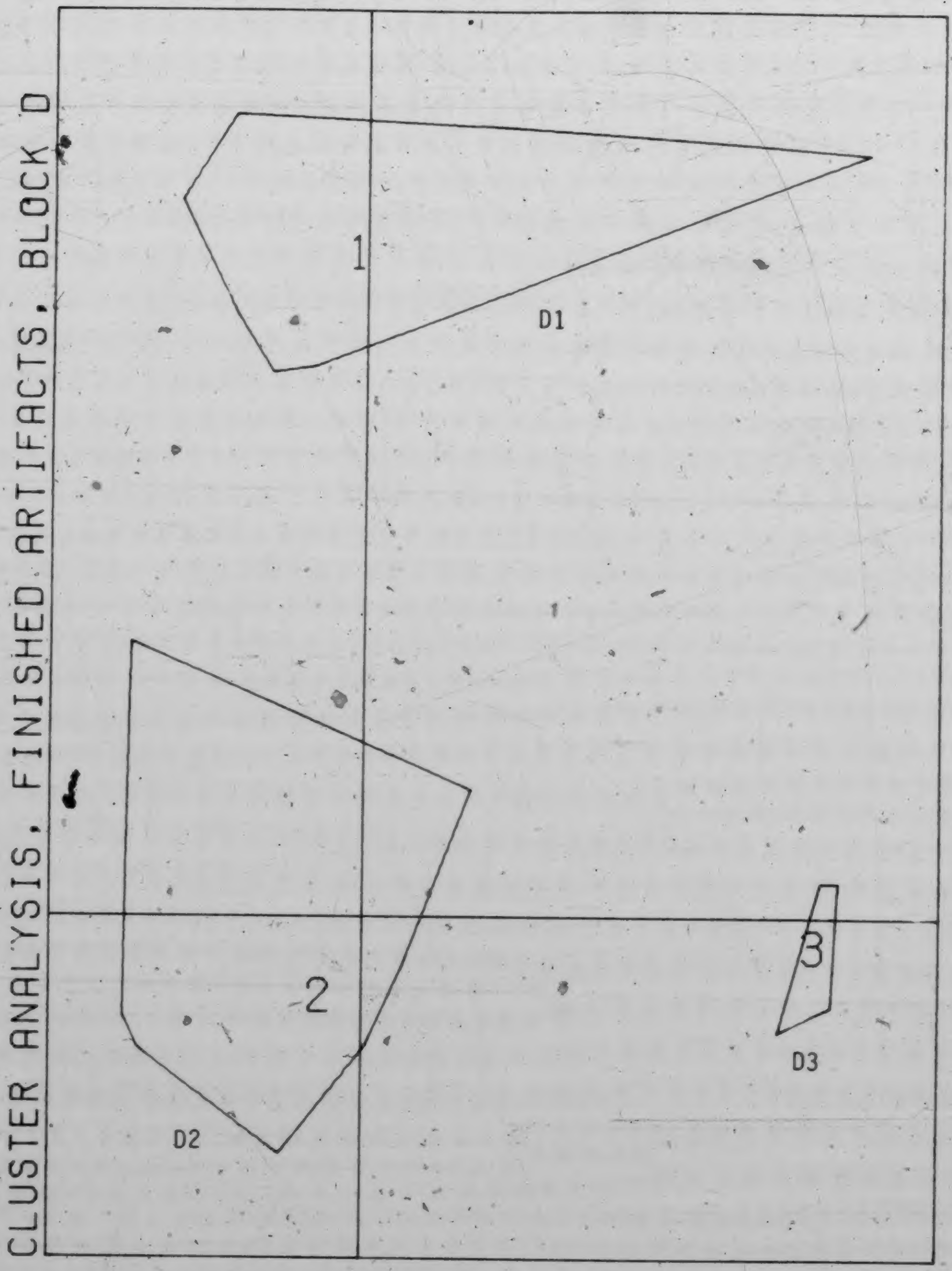
CLUSTER ANALYSIS, FINISHED ARTIFACTS, BLOCK D
1
D1
2
D2
3
D3

Figure 30. Spatial clusters outlined by convex hulls, Block D, HkPa 4. With slight modification, all three clusters were accepted.